University of Co-operative and Management, Thanlyin

Department of Statistics

# DEMOGRAPHY
# MAR 113

**FIRST, QUARTER**

UNIVERSITY OF CO-OPERATIVE AND MANAGEMENT, THANLYIN
DEPARTMENT OF STATISTICS

# Demography
# MAR 113

FIRST QUARTER

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## Unit I

## Scope and Importance of Demography

### 1.1 Introduction

The study of the numerical size, growth and characteristics of human populations has a long history. Ancient Chinese, Greek and Arab philosophers such as Confucious, Plato, Aristotle and Khaldum concerned themselves with the various population issues of those days. During the past three centuries, the interest in the study of human population has been revitalized by the words of European scholars such as John Graunt, William Petty, Thomas Malthus, Karis Marx and William Farr. These scholars were handicapped by the rather limited amount of population data available to them as in those days very few countries had conducted population censuses and kept records of births, deaths and other such events. Even those countries which collected population statistics did not do soon a uniform basis. In 1872 the international Statistical Institute recommended the principle of uniformity in the collection of population statistics. The adoption of this principle by many countries and similar recommendations by the league of Nations and its successors the united Nations have been instrumental in creating more and more interested in the study of human population which is the main concern of the modern social science called demography.

### 1.2 Demography

Demography is the science of population. The term 'demography' literally translated from Greek means 'description of the people'. According to the United Nations Multilingual Demographic Dictionary, "demography is the scientific study of human populations primarily with respect to their structure and their development".

The subject of matter of demography mainly concerns itself with the quantitative study of factors such as fertility, mortality and migration which continuously operate on a population and determine its size and growth and are referred to as 'components of population growth'. These factors along with others such as marriage, divorce, social mobility (i.e. change in social status), etc., determine the structure or composition of the population.

Two point must be mentioned her. Firstly, demography is concerned with the numerical data about the characteristics of human populations. These data are generally called 'demographic data' or 'demographic statistics'. Secondly, demographic analysis is usually carried out on a macro rather than a micro level, that is, demography is mainly concerned with the study of groups rather of individual human beings.

Changes in population size and composition have important social, economic, political and other implications for the persons living in a country.

## 1.3 The Scope of Demography

Hauser and Duncan regard the field of demography as consisting of a narrow scope-demographic analysis and wider scope-population studies.

Demographic analysis is confined to the study of components of population variation and change.

Population studies are concerned not only population variables but also with relationships between population changes and other variables – social, economic, political, biological, genetic, geographical, and the like.

Population studies as being concerned with the following questions related to three broad areas of study.

(1) What are the changes that are taking place in the size of the population, and hoe are these changes brought about? What is the significance of these changes from the standpoint of human welfare?

(2) Where are people found and what are the changes taking place in their distribution in communities and in areas?

(3) What kind of people are found in any given population group and how do those in one group differ from those in the other?

These questions clearly indicate that the study of population is concerned with

Its size or numbers, its structure and characteristics, its distribution and the changes taking place in it over a period of time. It is also implied in this description that the subject matter of population studies includes the study of fertility, mortality, migration and social mobility, that is, the components of change in the size, structure, characteristics and distribution of population.

## 1.4 The Importance of Demography

Demography is taken to include all statistical information relating to

- the size and growth of population;
- its age and sex composition;
- the regional distribution of the population and changes in such distribution;
- the movement of the people by immigration, and economic condition of the people.

These demographic statistics measures have increasingly varied application in the fields of the public health, local planning for land use, schools and hospital construction, public utilities, family planning programs, immigration and emigration policy, urbanization and regional development, population policy,.....The past levels of trends mortality and fertility is very important to estimate the national population projection.

# Lecture 1. Introduction to Demographic Analysis

## 1. Sources of population data

The main sources of population statistical data are: (a) censuses, (b) sample surveys, and (c) registration of migration and vital events such as births, deaths, marriages, and divorces.

### 1.1 Censuses and sample surveys

By international agreement, censuses consist of an enumeration of the population in a given area at a given time. Questions may be asked concerning certain characteristics of each Data on the number of persons in each subdivision of the area show the geographical distribution of the population.

Sample surveys person (age, sex, marital condition, etc.) at the same time that the count is made. Thus, censuses may provide data on the number and composition of the population at a given time. of the population may be made to obtain information about certain groups, such as school-age children, or to obtain information about all the population on a sample basis. Special inquiries on population characteristics are described in Unit II of the Atlantida case study.

Censuses and sample surveys usually provide a picture of the population at a given time. Some-times, however, questions may be asked in a census or in a sample survey to obtain dynamic population data, such as the number of children ever born to each woman who is enumerated (a question asked to obtain information on past fertility), or the place of residence at some earlier date (asked to obtain data on migration).

### 1.2 Registration of vital events and migration

The occurrences most commonly registered are births, deaths, marriages, divorces, and international migratory movements. Statistics are combiled from such registers at intervals to measure the amount and rate of change in the population.

Census or survey data on the number and characteristics of the inhabitants at a particular time, and registration data on events occurring throughout a period, can be used together in demographic analysis to measure change in the population. The basic formula for estimating the total population of an area at any given moment is as follows; The population

equals the number of persons at the time of the latest census, plus the number born since that the time, minus the number that have died, plus the number that have migrated into the area, minus the number that have moved out from the area. Registration data are most commonly used in combination with census or other data on the number of inhabitants to form rates or ratios. In the absence of usable registration data, vital rates may be estimated from census data under some conditions. By the same taken, registration data may be used in conjunction with census data for earlier dates to estimate the present composition of a population.

**1.3 Population registers**

Some of the European countries, notably Denmark Finland, the Netherlands, Norway, and Sweden, and some Asian countries, have maintained population registers on a current basic for many decades. Recently, other European countries have advocated the establishment of population registers. In these registers are recorded the name, address, and some data on the characteristics of each individual in the population. Periodically, statistical reports containing information similar to that published in census reports may be compiled from such registers.

In countries having population registers, generally every person is registered at birth in this community of residence. A record is maintained there, listing the occurrence of all changes in his civil status and family composition. If he moves to another community, an official transcript of his birth and his current civil and family status is sent to his new community.

To the extent that reporting is complet, population registers can provide the same data as a population census. The difficulty is that reporting is seldom complete, because reliance is placed on the individual; and failure to report, especially on changes of residence, can large errors over an extended period of time.

Most countries which maintain population registers also take population censuses at regular intervals. The census questionnaires are then used to correct and bring up to the data the information the registers, especially with respect to changes of residences, through information on additions to the family and changes in marital status are also obtained. At the same time, the register is used to check and complete the information on the census questionnaires regarding age, relationship to head of household, etc.

Another difficulty with data from population registers is that definitions and concepts may differ from those needed for population research. For example, the old population registration system of Japan considered a person to belong to the place in which his family home was situated long after he was a resident of a new district according to the model census definition.

Apparently population registers have always been established primarily for purposes of administrative control, though in the case of those countries that have maintained population registers for centuries the original purposes may have been forgotten or revised. Among modern nations they have been established in recent years for such administrative purposes as food rationing, housing rationing, settlement programs, etc.

It seems that the quantity of administrative detail and office work required for recording each change of residence and status in modern mobile population involves too much expenditure of time and effort for population registers to be maintained for purely statistical purposes.

## 2. Vital Statistics

By "vital statistics" are meant the number births, deaths, marriages, and divorces in an area.

A vital statistics system can be defined as "... including the legal registration, statistical the recording and reporting of the occurrence of , and the collection, compilation, analysis, presentation, and distribution of statistics pertaining to vital events, which in turn include live births, deaths, foetal deaths, marriages, divorces, adoptions, legitimations, recognitions, annulments, and legal separation."

### 2.1 Reporting procedures

Generally, a vital event such as a birth or death, is reported locally, in the registration office of the place where it occurs. At regular intervals each local registration office sends a statistical report on the number each type of vital event that has been registered and on certain specified circumstances of the events (such as number of mother at each age, number of infant s of each sex, etc. in the case of birth) to the central office which prepares and publishes the central statistical reports on vital statistics. The office is usually a division of

the central statistics bureau of the country, though in many countries it is a division of the health department.

**2.2 Availability Of vital statistics**

The availability of vital statistics varies widely. According to the United Nations, "this is due in part to lack of uniformity and universality in national legislation. In some areas, registration is compulsory only for births and deaths; in others, it is compulsory for only a small part of the population (that is, European or non- indigenous population). In still other countries... there is no national provision for compulsory registration, but only municipal or state ordinances which do not over the entire geographic areas which comprise only a part of the country, the country, the remainder being excluded for reasons of inaccessibility or because of economic and cultural considerations that make regular registration a practical impossibility".

It may be pointed out that even where vital statistics are available for only part of a country, they serve as a nucleus for future development of a vital statistics system.

**2.3 International recommendations on statistical report items for births and deaths**

The United Nations Statistical offices, after consultation which the Statistical commission and Population Commission of the United Nations and the World Health Organization as well as the vital statistics offices of its member nations, prepared a list of recommended items to be included in the statistical report forms for births, deaths, foetal deaths, marriages, and divorces.

2.3.1 Items of importance- The following items are considered to be of greatest importance as far as births and deaths are concerned;

(1) For births – Attendant at birth, date of occurrence, date of registration, legitimacy, place of occurrence, sex, type of birth (single or plural issue), date of birth of mother, number of children born to this mother, and mother's place of usual residence.

(2) For deaths- Cause of death, certifier, date of occurrence, date of decedent's birth, place of decedent's usual residence, and decedent's sex.

(3) For foetal deaths – Date of occurrence, place of occurrence, date of registration, legitimacy gestation period , sex, type of birth, date of birth of mother, number of children born to this mother, and mother's usual residence.

2.32 Comments on the items- The recommended items for reporting of births and deaths have several things in common;

(1) The date of occurrence of the events is required.

(2) The date of registration, as distinct from the data of occurrence, is required , since delayed registration of births, deaths, and foetal deaths may seriously affect the statistics for any given period.

(3) The place of usual residence of the persons concerned, as distinct from the place of occurrence, is an item of great importance for the registration of all vital events. This is because so many people are away from their usual place of residence during the occurrence of a major vital event that data by place of occurrence may be very misleading. For example , many births to rural parents and deaths of rural persons occur in city hospitals; the comparison of urban birth or death rates with rural requires that the place of usual residence be known.

(4) Date of birth of participants, or age in years if exact date of birth cannot be obtained, is of utmost importance for the interpretation of date on the number of events. For example, if there is an unusually small proportion of young women in a population because of a recent epidemic, and if these young women have the same number of children per woman during the year as is usual, then the total birth rate will be lower than usual. It is important in this case to know that the lower birth rate is a result of the unusual age distribution among women and, therefore, is a temporary phenomenon and not an indication of a major change in customs or family patterns. Similarly, an increase or family patterns. Similarly, an increase or decrease in number of marriages per total population may not mean a change in proportions of persons marrying. On the other hand, an increase in proportions marrying at younger ages presages an increase in the birth rate. Almost all analysis of statistics on vital events requires knowledge of the ages at which they occur.

(5) The sex of the persons dying is of importance for the analysis of causes of death and of age-sex structures of the population. The sex of infants born is of statistical importance

primarily because a ratio of about 1.05 males to females is normal, and if the reported ratio differs much from that figure, it is an indication of poor registration of births.

**2.4 Defects in the registration**

An important consideration in evaluation vital statistics of a country from its civil registration is the legal provision them. If a fee is charged for registration, it is probable that registration will be less complete than otherwise. If family allowances or wages are increased with each addition to the family, birth registration may be very complete but death registration may not be. Any added incentive to register vital events tends to increase the completeness of the registration, and any inconvenience or fee tends to decrease it.

If both birth and death registration are incomplete, and by about the same proportion, the data may be used for many purposes. This situation may occur in countries where the chief deterrent to registration is the long distance from isolated rural areas to the registry offices. In these countries, the under registration may not be selective. It is also true that in many countries it is better to use the vital statistics of only a few urban centers where registration is good, than to use statistics for the country as a whole.

If births are more completely registered than deaths or vice versa or if under registration selective in other respects such as age, sex, etc., the distortion is more serious.

Delays in registration may also have serious effects on vital statistics, especially in periods of rapid change in rates, and especially if the delay is longer than a year. Not only may more or fewer vital events be recorded during the year than actually occurred, but they are related to the wrong population in the computation of rates.

**2.5 Comparison with census data**

If we have the population counts from two successive censuses, then the total number of births and deaths occurring during the intercensal period and the net migration during the same, period should account for the change in the total population between the two censuses. One trouble with this comparison is that a country with poor vital statistics may also have rather poor censuses and very probably will have poor migration statistics. Another difficulty is that in a country where birth registration is as good or better than death registration, the indicated natural increase may equal the population increase measured by the censuses even though registration of both births and deaths is inadequate.

However, it is more usual to find that the reported births and deaths do not add up to anywhere near the increase (or decrease) found by the censuses, and that even the highest possible estimates of net migration cannot make up the difference.

If the census and the registration are both reasonably reliable, then the age-specific death rates should not be too different from the survival ratios indicated by the census. Thus, if the ratio of the group aged 40-50 years to the group aged 30-40 in the census 10 years earlier is 0.985, then the annual death rate should not be too far from 15 per thousand. However, even with perfect statistics there would be some difference between the death rates because of changes in the rates during the intercensal period. Net migration also might alter the relationship.

**2.6 Consistency of the vital statistics**

If the reported number of births or deaths varies markedly from year to year, especially if the movement is erratic (sometimes much larger and sometimes much smaller), and there are no known factors causing the variation, it is reasonable to consider the registration quite poor.

Also, if the reported numbers of vital events by age are very different from one year of age to another sign of poor registration. In this case, however, the discrepancies may be due to errors in age reporting. The data should be examined for successive years to see if the reported births by age of mother and deaths by age regularly cluster around certain ages, which might be consider "attractive" ages (see lecture 2).

It can be expected that the registration would show many more deaths for the first month of life then for later months; more for the first year of age than for later ages; and beginning somewhere about age 10, more for each later year of age. If this is not true, it can be assumed that registration of deaths is probably poor.

Examining the sex ratio at birth (ratio of the number of males to females) is another way of evaluating the adequacy of the birth registration. The sex ratio at birth should be about 1.05 or 1.06, since it is known that in most of the world about 5.or 6 percent more boys than girls are born. A ratio much different from 1.05 or 1.06 may indicate inadequate registration of one or both sexes.

### 2.7 Reasonableness of the data

Frequently the decision regarding the quality of registration data must be made on the basis of the reasonableness of the data in the light of what is known about general mortality and fertility levels in the country and the age-sex structure.

Apparent increases in fertility or mortality, especially in developing countries which have always had high fertility and mortality, are usually due to improved registration of the events.

Apparent higher death in more prosperous areas of the country than in poorer ones are usually due to better registration in the more prosperous areas. In many countries this is true also of birth rates, though a reversal here may reflect a true change in the rates, especially if an improvement in the economic situation and the spread of birth control practices are concomitant.

## 3. MIGRATION

Migration is defined as a change of residence in which a recognized boundary of one type or another is crossed. The distinction between the migrant, who goes from one place to another and takes up residence in the second place, and the traveler, who may follow the same route but who soon returns to his residence in the first locality, is a fundamental one which must be maintained in any study of migration. Many itinerant workers have no homes other than the temporary quarters in which they live while working on each job. Such persons present special problems in the study of migration.

In practice, it is almost always necessary to treat international migrations and internal migrations separately because of differences in the sources and nature of data. Counts of international migrants, often classified by age and sex, are available for recent years in many countries. Such direct measurements are rarely, if ever, available for migrations within a country.

### 3.1 Internal migration

There are several different types of internal migration. Rural-urban migration is the movement from rural to urban areas, often involving short distances. Interregional migrations take place between different regions of the same country. Expanding frontiers might be regarded as interregional movements of a special type; usually, however, they involve

migration over shorter distances from areas which have been recently settled into areas which are still relatively uninhabited. Seasonal movements of itinerant workers, especially agricultural laborers, are usually ignored in general population studies, in part because they are difficult to measure.

It is customary to restrict the terms "immigration" and "emigration" to international migration and to use the terms "in-migration" and "out –migration" for internal migration.

The techniques used to estimate the size and composition of internal migrations may be the same regardless of the type of migration. Two types of census data may be used: Data on place of birth and data on place of former residence. In addition, where birth and death registration are essentially complete, migration may be treated as a residual element of change; that is , derived from the basic formula of population growth.

The amount of total movement is not measured by a census. Some people have moved out of the area and then moved back in again before the census, so that the census reports no movement in their cases; others have move several times, while the census reports only one movement, either from their place of birth or from their place of residence at a given time; others have moved once or several time and then died before the census , so that no movement is reported for than in the census.

### 3.2 International migration

International migration – that is, migration between different nations-is of two types with respect to any particular population. Immigrants are departing international migrants. Emigrants are arriving international migrants. Obviously, the immigrant in one country is an emigrant from another country. This relationship is useful for purposes of evaluation when emigration statistics are available by country of destination .If there are large differences-for example , between the number of emigrants from the United Kingdom destined for the United States(as reported by the United Kingdom) and the number of immigrants into the United States coming from the United Kingdom)and the number of immigrants into the United State coming from the United Kingdom (according to the United States statistics ) in the same year – something is wrong with one or the other or both , of these figures.

3.2.1 **Sources of data** – Data on international migration are collected in several different ways by the different countries, including port statistics, frontier control data , passport data, local population registers, and statistics obtained in connection with

enforcement of regulations concerning immigration , work permits for aliens, transport contracts for emigrants, etc. It is necessary to remember that the methods employed in collecting and tabulating such statistics can and do have some effects on their quality. The definitions and classifications employed can produce substantial differences in the results: sometimes, however, such differences may cancel each other out to a large extent .

Most countries publish immigration and emigration statistics in their statistical yearbook; some publish special statistical reports on immigration and emigration. In addition, several of the issues of the United Nations Demographic Yearbook which have appeared to date have included data on international population movements.

Most migrations work in both directions; that is, data on arrivals alone are not sufficient to study the effects of immigration on a population ,because some of the immigrants return to their place of origin and others go on to still other countries. Net migration, or the difference between immigration and emigration , is more commonly of direct interest in population than gross movements to and from a country or between two particular countries. Nevertheless, net migration usually must be found from data on both immigration and emigration.

Statistics on migration between two countries which share a common land boundary are likely to be subject to much larger errors than those on intercontinental migrations. Errors are likely to be especially large if there are substantial differences in levels of living between the two countries and if the country with the higher level of living places some restrictions on immigration from its neighbor, causing much legal unrecorded migration. Under such circumstances, it is extremely difficult to estimate the true magnitude of the net migration from either international migration statistics or census data.

**3.2.2 Selectivity of international migration-** Migration of all types draws more heavily on some parts of the population than on others. That is, migrations are selective of certain elements of the population from which the migrants are drawn. Intercontinental migrations usually draw most heavily upon males in the young adult ages. Exception to this general finding regarding age structure of migrants sometimes occur in the case of migration resulting from political occurrences; for example, refugee movements, transfers of population, etc.

# 4. BASIC DEMOGRAPHIC MEASURES

Much demographic analysis is done with the all of only a few very simple statistical measures. Even very sophisticated analysis may employ only a few elementary devices. An important concern in analysis lies in understanding the limitations of the data, the methods by which the data were collected, the kinds of classifications used, and the manner in which the classifications may have affected the reported figures. Another concern in analysis is the effect on the population of economic, social, and cultural factors.

## 4.1 Percentage

A percentage is the size of one figure in comparison with another, translated into a proportion of 100 in order to make it easier to compare the relationships between different sets of figures. For example, it is easier to see that the relationship of 152 to 608 is the same as the relationship of 719 to 2876 if both quantities are translated into percentages; it is found that in both cases the first number is 25 percent of the second.

A percentage is obtained by dividing one figure by the other, then moving the decimal point in the result two places to the right (that is, multiplying by 100):

$$\text{Percentage} = \frac{a}{b} \times 100$$

The only problem is to decide which figure is to be related to the other, or whether each is to be related to the total of the two. For example, if the rural population of an area is 6,000,000, and the urban population is 4,000,000 then the following three statements are true:

(1) The rural population is 50 percent larger than the urban population;

(2) The urban population is 66.7 percent as large as the rural population;

(3) The rural population is 60 percent of the total population and the urban population is 40 percent of the total population.

In a cross-classification, the table is very different if percentages are presented one way instead of another. The table below presents figures on literacy for urban and rural populations. The three examples which follow show the different percentages which may be obtained from the same figures.

| | Total | Literate | Illiterate |
|---|---|---|---|
| Total | 1,000,000 | 800,000 | 200,000 |
| Urban | 360,000 | 320,000 | 40,000 |
| Rural | 640,000 | 480,000 | 160,000 |

Example 1. Urban-rural distribution of literacy (in percentages).

| | Total | Literate | Illiterate |
|---|---|---|---|
| Total | 100 | 100 | 100 |
| Urban | 36 | 40 | 20 |
| Rural | 64 | 60 | 80 |
| | | | |

Example 2. Literacy and illiteracy in the urban and rural populations (in percentages).

| | Total | Literate | Illiterate |
|---|---|---|---|
| Total | 100 | 80 | 20 |
| Urban | 100 | 89 | 11 |
| Rural | 100 | 75 | 25 |

Example 3. Literacy and urban-rural distribution of the population (in percentages).

| | Total | Literate | Illiterate |
|---|---|---|---|
| Total | 100 | 80 | 20 |
| Urban | 36 | 32 | 4 |
| Rural | 64 | 48 | 16 |

### 4.2 Ratio

A ratio expresses the size of one number in relation to the size of another number. For example, 140 is twice as large as 70; thus the ratio of 140 to 70 is 2. Likewise, 70 is one half the size of 140; thus the ratio of 70 to 140 is 0.5.

A percentage is one form of a ratio; it is a ratio based on 100. When we say above that the ratio of 70 to 140 is 0.5, we are using a ratio based on 1. The same considerations which apply to percentages apply to all ratios; basically, the problem is to decide which number is to be expressed in terms of its size in relation to the other.

A ratio is obtained by dividing the number which serves as the basis of comparison into the number which is being compared to it. If the question is "How many units of a are there per unit of b? the formula is:

$$\text{Ratio} = \frac{a}{b}.$$

### 4.3 Proportion

A proportion is a ratio in which the relative size of one number is expressed in terms of a total consisting of that number plus another number. That is, it is the relative size of a part compared with the size of the whole. The formula is:

$$\text{Proportion} = \frac{a}{a+b}.$$

For example, if the rural population of an area is 300,000 and the urban population is 100,000, then the proportion of the total population which is rural is 0.75, or

$$\frac{300{,}000}{300{,}000+100{,}000} = 0.75$$

Of course this is usually obtained directly by dividing the total into the part, or

$$\frac{300{,}000}{400{,}000} = 0.75$$

Like other ratios, proportions are frequently multiplied by 100 and expressed as percentages; for example, the rural population is 75 percent of the total population.

### 4.4 Rate

A rate is a ratio of one thing to another in a specified period of time. A birth rate is the ratio of births during a specified period to the population at the middle of that period. Most of ten rates in population statistics are expressed the terms of years, but a rate may be computed for any other time period such as a week, month, quarter, decennium, etc.

Population rates are usually given as the number of events which occurred per1,000 inhabitants. For example, if there were 40 births per 1,000 in habitants during the year, the crude birth rate for the year was 40. Likewise, if there were 20 deaths per 1,000 inhabitants during the year, the crude death rate for the year was 20. If a given type of event is so uncommon that it would be necessary to use numbers to the right of the decimal point in a

rate expressing its occurrence per 1,000 in habitants per year, it may be preferable to base the rate on 10,000 or even 100,000 inhabitants. The death rate from a single cause of death is usually given per 10,000 or even 100,000 habitants. For example: "The death rate from malaria was 57 per 10,000 inhabitants in 1940 whereas it had been 135 per 10,000 inhabitants in 1920; by 1955 it had dropped to per 100,000 inhabitants."

The number of which occurred during a given period is the numerator of a rate, and the population in which the events occurred is the denominator. For most vital statistics rates, the estimated population at the exact middle of the period is used. For example, the number of deaths reported in Madagascar in 1955 was 62,436, and the estimated midyear population in 1955 was 4,776,000; the crude death rate per 1,000 population was 13.1 or

$$\frac{62,436}{4,776,000} \times 1,000 = 13.1.$$

Care must be taken calculation of rates to be sure that the population in the denominator is really the population among which the events in the numerator occurred; or, as it is usually said, care must be taken to use the population which was at risk of the event in the numerator. For example, if there is in a country some remote area which is too far from any local registrar for the deaths occurring in that area to be reported, then the reported deaths in the numerator exclude the area; therefore, the population in the area should be excluded from the denominator as well.

**4.5 Rate of growth**

If there were 100,000 people in an area at the beginning of a year and110,000 at the end of the year, the increase was 10 percent and there were 10,000 additional people. If the population increases by percent the next year, it will increase by 11,000 and the population at the end of that year will be 121,000. If it increases by 10 percent the third year, there will be 12,100 more persons at the end of the year, and the total population will be 132,000. That is, if the rate of increase is 10 percent each year, then each year a larger number of people are added to the population, because each year the 10 percent is a percentage of a larger number.

If the analyst knows that the population was 100,000 at the beginning of the three years and 132,000 at the end, then he can calculate that the average annual rate of increase during the three years was 10 percent. Of course, it is unlikely that the increase each year was exactly 10 percent; it was probably a little less than 10 percent one year and a little more than

10 percent one year and a little less than 10 percent another year. For example, it might have been 9 percent (100,000 to 109,000) the first year, 10 percent (109,000 to 119,000) the second, and11 percent (119,000 at 132,000) the third. An average annual rate of increase assumes a constant rate of increase each year, which is recognized to be at least a little fictitious in almost all cases.

If the population is known for two dates, then the average rate of increase can be found by the formulas,

$$P_2 = P_1(1 + r)^n$$

or

$$r = \sqrt[n]{\frac{P_2}{P_1}} - 1$$

where

$P_2$ is the population at the end of the period.

$P_1$ is the population at the beginning of the period.

r is the average rate of increase per unit of time.

n is the number of units of time – years, months , etc.-from the beginning to the end of the period .

A rate of increase is easier to calculate with logarithm. In terms of logarithms , the formulas given above are as follows:

$$\log P_2 = \log P_1 + n \log (1+r)$$

or

$$\log (1+r) = \frac{\log P_2 - \log P_1}{n}$$

For example, the computation of the rate of increase of the population of a country between the 1950 and 1960 censuses would give

$$\log (1+r) = \frac{\log 681{,}187 - \log 531{,}818}{10}$$

Using a table of logarithms, we insert the logarithms for each of the two populations:

$$\log (1+r) = \frac{5.833158 - 5.725161}{10} = \frac{0.107997}{10}$$

$$\log (1+r) = 0.010800$$

$$(1+r) = 1.0252$$

$$r = 0.0252, \text{ or } 2.5 \text{ percent average annual rate of increase.}$$

Rate of increase are frequently calculated for each Province or State and are compared with each other or with the rate of increase of the population of the nation as a whole. Comparisons may also be made of the respective rates of increase of the urban and rural populations, or of other groups of the population.

As has been explained, the average annual rate of increase for any period of years assumes a constant rate of increase each year. If, in fact, there have been major fluctuations in rates of growth (such as a sudden sport of growth in the few years immediately preceding the most recent census, or conversely a rapid growth at the beginning of an intercensal period and a leveling off toward the end) then the average annual rate of increase for the entire period gives a misleading impression. If there is reason to believe that the rate of growth during part of the period was very different from the average rate for the entire period, it is probably better not to present figures for the average annual rate of growth for the entire period, If the average annual rate is presented in such a situation a note regarding the presumed changes in the rate of growth during the period should accompany it.

If the analyst known the population at the beginning or end of a period, and knows the average rate of growth, then he can obtain an estimate of the population at any other time during the period by using the formula,

$$\log P_x = log\ P_1 + n \log (1+r)$$

For example, if we known that the population of a country was 531,818 in 1950 and that the rate of increase between 1950 and 1960 was 0.025, then it is possible to estimate that if growth between 1950 and 1960 was at a constant rate , the 1953 population ($P_x$) was approximately 572,000:

$$\log P_x = log\ P_1 + n \log (1+r)$$

$= \log 531{,}818 + 3\log(1+0.025)$

$= 5.725161 + 3(0.010800)$

$= 5.725161 + 0.032400$

$= 5.757561$

$P_x = 572{,}220$ or, rounding to three significant digits, 572,000

If the analyst knows the present population and present rate of increase, he can estimate the length of time if will take for the population to reach some given size if the rate of increase remains constant. In this case, the formula is expressed as:

$$n = \frac{\log P_x - \log P_1}{\log(1+r)}$$

For instance, if the population in 1958 is 879,000 and the rate of increase is 2.5 percent a year, then it can be estimated that the population will reach 1,000,000 in approximately 5 years if the present rate of increase continues:

$$n = \frac{\log 1{,}000{,}000 - \log 879{,}000}{\log(1+0.025)}$$

$$= \frac{6.000000 - 5.943989}{0.010724}$$

$$= \frac{0.056011}{0.010724}$$

$= 5.2$ years

## Study Assignment

Exercise1. In a recent census, there were 2,788 children 0 to 4 years old – 1,325 girls and 1,463 boys .The total population consisted of 27,109 males and 27,469 females.

(a) What proportion of the total population was 0 to 4 years old?

(b) What proportion of the total population were male children 0 to 4years old.

(c) What proportion of the total male population were male children 0 to 4 years old?

Exercise2. In Bermuda in 1960, there were 365 deaths and 1,200 births. The population of Bermuda was 43,000 at midyear.

(a) What was the crude death rate per 1,000 inhabitants?

(b) What was the crude birth rate per 1,000 inhabitants?

Exercise3. The population of a country grew from 756,000 in 1950 to 1,013,000 in 1960.

(a) What was the average annual rate of increase?

(b) What was the estimated population in 1955?

(c) What was the estimated population in 1965, assuming the same average annual rate of increase as occurred between 1950 and 1960?

(d) How long would it take the population to reach 2 million, assuming the same average annual rate of increase as occurred be between 1950 and 1960?

# Lecture 2. Sex and Age

## 1. Sex Composition

The importance of the sex composition of a population is so widely recognized that a classification of the population by sex is universal in modern censuses. Few problems are connects with the collection of data on sex composition. The classification of each individual in the population as either male or female is simple and straight forward; it is probability subject to fewer reporting errors than any other item on the census questionnaire. Such errors as exist in the tabulated data on sex composition are caused almost entirely by errors of coverage; that is by the selective net under numeration of persons of one sex and of certain age groups.

### 1.1 Sex ratio

The sex ratio is the basic tool for the analysis of the sex composition of populations. It is defined as the number of males per 100 females. This measure is to be preferred to others, such as the number of females per 100 males, or the percentage of the total population made up of either males or females, because it is the conventional one used in population studies throughout the world.

The sex ratio is calculated by dividing the number of males by the number of females and multiplying by 100; for example, the sex ratio of the total population of India in 1961 is as follows:

$$\frac{Number\ of\ males}{Number\ of\ females} \times 100 = \frac{226{,}060{,}908}{212{,}713{,}821} \times 100$$

$$= 1.063 \times 100$$

$$= 106.3$$

Three classifications reflecting variations in the sex ratio – age composition, rural-urban and regional residence-are discussed below.

### 1.2 Age composition by sex

It is well established that males outnumber females at birth (the sex ratio at birth is normally about 105.5). Therefore, a "young" population, in the sense of a population in which young persons make up an unusually large percentage of the total population, may be

expected to have a high sex ratio if there are no other causes; such "young" population are generally characterized by high birth rates (the example above illustrates a country with a young population and high birth rate). Conversely a low sex ratio may be expected in a population in which older persons make up an unusually large percentage of the total population.

The sex ratios in table 2A illustrate the pattern that is expected for countries with an older population.

Table 2 A. SEX RATIOS IN SWEDEN: 1960

| Age group | Males | Females | Sex ratio |
|---|---|---|---|
| Total..... | 3738881 | 3756435 | 99.5 |
| 0-4 years..... | 259950 | 245281 | 106.0 |
| 5-9 years..... | 274208 | 259278 | 105.8 |
| 10-14 years..... | 312550 | 297639 | 105.0 |
| 15-19 years..... | 303288 | 290994 | 104.2 |
| 20-24 years..... | 235839 | 230406 | 102.4 |
| 25-29 years..... | 219838 | 215572 | 102.0 |
| 30-34 years..... | 236320 | 233828 | 101.1 |
| 35-39 years..... | 268828 | 264694 | 101.6 |
| 40-44 years..... | 270523 | 265476 | 101.9 |
| 45-49years..... | 268942 | 264831 | 101.6 |
| 50-54 years..... | 261154 | 260761 | 100.2 |
| 55-59 years..... | 226190 | 235224 | 96.2 |
| 60-64 years..... | 190946 | 205538 | 92.9 |
| 65-69years..... | 152478 | 173330 | 88.0 |
| 70-74 years..... | 115862 | 137806 | 84.1 |
| 75 years and over... ..... | 141965 | 175777 | 80.8 |

Source: United Nations. Statistical Office. Demographic Yearbook, 1963. New York,1964.

By age, males outnumber females at the earlier ages, and females outnumber males at the later ages. Also, mortality is higher among males at most ages in most societies. The

larger the death rates in a population, the younger the age at which women begin to be numerically preponderant.

### 1.3 Rural-urban difference

In Western civilizations, urban areas characteristically have lower sex ratios than the surrounding rural populations, at least in part because rural-to-urban migration is ordinarily higher for females. In Eastern civilizations, the reverse is true.

### 1.4 Regional differences

Areas which are receiving migrants who have come from distant places are normally characterized by high sex ratios because long-distance migrations are ordinarily selective of males. Conversely, areas which are losing migrants in long-distance migrations ordinarily have low sex ratios.

Frontier regions are characterized by especially high sex ratios because frontier migrations are as a rule unusually selective of males. The boisterous nature of frontier society is often attributed to the relative lack of females in frontier populations.

## 2. AGE COMPOSITION

The classification of the population by age, like the classification by sex, is universal in modern population censuses. There can be little doubt about the importance of the age composition of a population: almost all population characteristics and processes vary considerably with age. Mortality rates vary over a wide range at different ages. The bearing of children is associated with only a limited part of the life span of women. The age composition of a population, through its relationship to the number of dependents per worker, is indirectly associated with levels of living. The very young are economically inactive, and in some societies one's economic characteristics are a function of his age, in combination with other factors, throughout life. Marital status is closely associated with age.

The age composition of a population is so closely linked with its other characteristics that it is essential to take the age factor into account in comparing two or more populations which differ in age composition. Otherwise, apparent differences which are due only to variations in age composition may be ascribed to other factors such as rural-urban composition or ethnic composition.

## 2.1 Definition of age

Age is defined as the number of complete years which have elapsed since the birth of the individual. In other words, the data on age should refer to ages of individuals at their last birthday.

## 2.2 Collection of data

Data on age may be obtained by asking either for exact date of birth or for age at last birthday. If the question is on date of birth, then the processing operation must convert the responses to age in complete years. This approach is likely to yield more precise age data than a direct question on age, since such a question is more likely to receive approximate replies. If a considerable proportion of the population cannot give their exact date of birth, then it is better to ask for age in years.

Even if age in complete years is asked, the accuracy of reporting early ages may be improved by asking age in completed months for children under 1 year of age, to be sure that children nearly 1 year old are not erroneously reported as having passed their first birthday.

## 2.3 Classification

The United Nations and the regional organizations recommend that at least one table for the total country and the major administrative regions be presented by single years of age and sex. This table can provide information on the number of males and females in such categories as "preschool age" and "school age". "voting age", and other special age categories needed by the analysis . Data by single years of age are also useful for estimating the accuracy of age reporting.

Age data are classified by 5-year age groups for some tables and by 10-year age groups for others. Grouping the single- year age data not only provides briefer tables but also servers to smooth out the pronounced irregularities which appear in the single –year data because of the preference for years ending in certain digits.

The 5-year age group tables that begin with age 0 usually separate the first group into (a) under 1 year , and (b) 1-4 years . The other groups are 5-9 years, 10-14 years, and so on , to 75 and over. The 10-year age group tables usually begin with 0-4 years, then continue with age groups 5-14,15-24,25-34, etc. The purpose of this is to place the years ending in 0 , such

as 20,30,etc.,in the middle of the groups, because so many persons both over and under the ages ending in 0 report themselves at those ages.

## 3. ERRORS IN AGE COMPOSITION

Census data on age are subject to several types of error. Selective net under enumeration of infants and young adults, rounding –off of ages to "attractive" numbers, and deliberate misstatement of age all influence the quality of age data reported in a census.

The definition of the total population may also affect the age-sex composition of the enumerated population, since the groups which may be either excluded or included, such as the Armed Force abroad or foreign armed forces stationed in the country, are usually of selected ages.

### 3.1 Under enumeration

Selective net under enumeration usually leads to understating the figures for two types of persons. This defect is characteristic of virtually all censuses.

3.1.1 Under enumeration of infants and young children. Young children, especially those under 1 year of age, are usually under reported. This can be demonstrated on a national scale by comparing the number of persons reported to be under 1 year of age in one census with the number of persons born in the same year in the succeeding census (that is , persons 10 years old in the second census if the two censuses were taken 10 years apart).Of course , if vital statistics are known to be accurate, the most reliable method is to use data on births and infant deaths in the year preceding the census to estimate independently the number of children under 1 year old who were alive on the census date.

Relatively few attempts have been made to date to measure precisely the extent to which infants and young children are omitted from censuses mainly because other statistics on such persons are at least as incomplete as the census in most countries. On the basis of relatively complete birth and death registration data, it has been estimated that 802,000 persons under 5 years old, or 4.7 percent of the estimated total population of that age , were omitted from the 1950 U.S. Census of Population or were misclassified in some older age group. Of these children, 638,000 were less than 2 year old; they accounted for 9.0percent of the estimated total population of that age. Studies in some other countries indicate

considerably higher percentages of young children missed in the census – more than 15 percent in some instances.

3.1.2 Under enumeration of young adults. -Comparison of cohorts of persons born in the same 5 – year periods from census to census in countries around the world which have taken repeated censuses indicated that young adults are characteristically selectively omitted from censuses. This net under enumeration is more common among males than among females, and is in part responsible for variations between expected and observed sex ratios by age.

## 3.2 Misstatement of age

In every census there is a tendency toward the concentration of population in certain "attractive" ages. In most countries , the numbers for ages ending in 0 and 5 (and perhaps in the years ending in 2,4,6, and 8 to a lesser extent) are large relative to what may be expected ; on the other hand, the number for ages ending in 1,3,7, and 9 may be relatively small. Such variations cannot be explained satisfactorily on the basis of differences in fertility or mortality or by the influence of migration. They occur at the same ages in census after census, and in country after country.

Special legal situations can lead to deliberate misstatement of age. Thus in a country in which the law specified that children legally become adults at age 18, there might be a tendency for persons a little under 18 years of age to report that they have passed their $18^{th}$ birthday . Also, there might be consider able tendency for persons a little under 65 years old to report that they have passed their $65^{th}$ birthday in a country in which they become eligible for old – age pensions at 65.

In analysis, any unusual clustering of population at certain ages should lead to the question as to whether there are legal or social benefits associated with those ages.

The pattern of age-sex distributions in census results throughout the world has led to the assumption that there were three usual types of deliberate misstatement of age:

(1) The sex ratios by age in most countries led to the conclusion that adult women tend to understate their true ages.

(2) The age distributions suggest that the very old tend to overstate their age.

(3) There seems to be considerable reluctance in some areas to report age 0 for persons under 1 year old, and consequent reporting of many of these infants as 1 year old (which is the reason the age in months is sometimes asked for all infants under 1 year of age ).

However, recent post-enumeration surveys of census accuracy, and checks of reported ages on census questionnaires against birth registrations for the same persons, indicate that errors in age reporting are more random than had been supposed. That is, it has been found that ages of women and very old persons and infants were about as likely to be overstated as to be understated. If this is true, then the observed inaccuracies in the age-sex distributions could be almost entirely attributable to selective under enumeration in the census.

## 4. AGE RATIOS

The reliability of data on the age composition by 5-year age groups is usually of more concern to the analyst than the accuracy of reporting of single years of age. It is possible to evaluate the data by age groups on the basis of age ratios. Generally, one would expect the number of persons in one age group to closely approach the mean of the number in each of the two adjacent age groups. An age ratio compares there two numbers by dividing the reported number of persons in the age group by the number "expected" on the basis of the number of persons reported in each of the adjacent age groups. The age ratio per100 females aged 25 to 29, for example, is arrived at as follows:

$$\text{Age ratio female 25-29} = \frac{females\ 25-29}{\frac{1}{2}(females\ 20-24+females\ 30-34)}\times 100$$

$$= \frac{200\times females\ 25-29}{(females\ 20-24+females\ 30-34)}$$

According to the 1960 data for Sweden, in table 2A the age ratio for females 25-29 would be-

$$\frac{200\times 215,572}{230,406+233,828}=92.9$$

Age ratios can be calculate for each age group (provided the intervals are equal) except the youngest and the oldest.

Generally, age ratios should be studied for a series of age groups, preferably for the entire span of age for which they can be calculated. An age ratio under 100 implies that either (a) members of the group were selectively under enumerated or (b) errors in age reporting resulted in misclassifying persons who belonged in the age group. A ratio of more than 100 suggests the opposite of one or the other, both, of these conditions.

Tentative conclusions may be reached on the basis of age ratios for a single census. The conclusions carry much greater weight, however, when it is found that the same pattern of age ratio is repeated in successive censuses, for in such cases the hypothesis that departures from 100 are due to true differences in age composition usually can be rejected.

## 5. UNKNOWN AGES

Persons for whom no age is reported often have been included in the tabulations by age in a special "age unknown" class. Some countries make it a practice to assign ages to individuals of unreported age, taking into account their other characteristics and characteristics of other members of their households. Such a system can take advantage of the available information to improve the quality of the data in this respect.

The United Nations recommends that: "Persons whose ages are not stated should be classified as a separate group, expect where the number of such persons is negligible ,when ages may be assigned to simplify tabulation. Such assignment should be to randomly selected ages, appropriate to the other characteristics of the individual and the household .If such allocation is employed, the method used and the number of cases should be clearly described in the census report".

The "assignment to randomly selected ages appropriate to other characteristics of the individual and of the household" must be done as part of the processing of the questionnaires prior to tabulation. The result is a table in which the problem of persons of unknown age has been solved by the statistical office; the "unknowns" do not appear as such in the table.

If the table presents a group of "ages unknown"(as it might if the group is at all large), then the user must decide how the "unknown" group should be treated in analysis. Usually it is assume that failure to report age in equally characteristic of all age groups. In that case, the unknowns are either (a) eliminate from the distribution before calculated percentages, or (b) distributed proportionally among the known ages. The choice between these two alternatives depends upon the use to be made of the data. If counts by age are to be used only to arrive at

percentages, rates, or ratios, the first alternative may be the wisest choice. If the absolute numbers are to be used for population estimates by age, then the second alternative is preferable.

If it is decided to distribute persons of unreported age proportionally among the known ages, the procedure is to (a) compute the percentage distribution of the population with known ages then (b) apply these percentages to the total population including the "unknown" group.

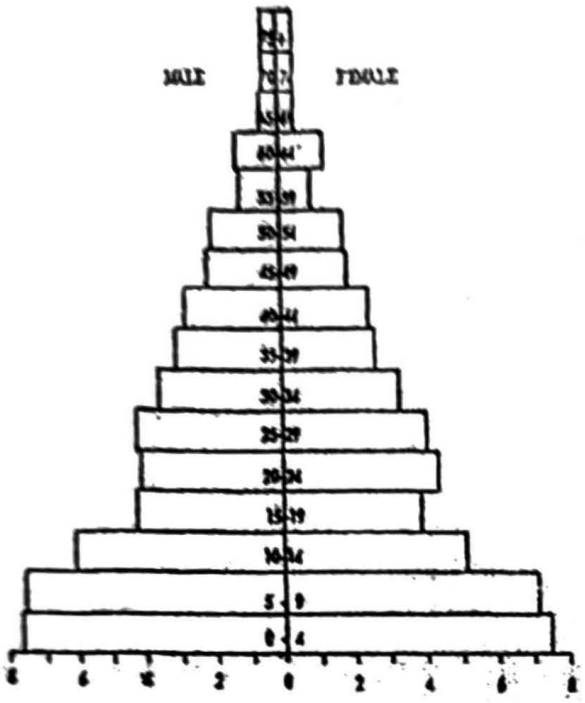
## 6. AGE- SEX PYRAMID

The age-sex pyramid is a common graphic device for studying age structure. In effect, it records the history of a population through the lifetime of persons living at the time of the census. Wars, famines, and migration, as well as the general levels of fertility and mortality, all make their mark on the age structure of the population, and all are apparent in the age-sex pyramid.

Data on the composition of the population by sex and 5-year age groups are preferred for the construction of age-sex pyramids. Pyramids based on data by single years overemphasize the rounding-off of ages to such an extent that it is often difficult to see more significant features. On the other hand, important features may be lost to a considerable extent if 10-year age groups are used.

Basically, an age-sex pyramid is a bar chart in which all the bars taken together represent 100 percent of the population. The length of each bar (expect for the oldest age group) is directly proportional to the percentage of the population made up of persons in the age-sex group it represents. Below is an age-sex pyramid illustrating the age-sex composition of the population of India in 1961; the data are shown in tabular form in table 2B.

AGE-SEX PYRMID FOR INDIA: 1961



Percent

Two or even three age-sex pyramids may be partly superimposed in order to compare the age structure of two or three different populations or the same population at two or three different dates. If more than three populations are to be compared, separate pyramids are recommended.

## 7. FACTORS AFFECTING AGE COMPOSITION

The age composition of a population can be directly influenced only by the same factors (births, deaths, and migration) which directly influence the total number of inhabitants. Other factors can create differences in age structure only through their influence on any of the three mentioned.

The general conformation of the age structure of a population, as it is reflected in the age-sex pyramid, is usually set by the levels of fertility, mortality, and migration which have prevailed during the three or four preceding generations. It is the level of the fertility rate which is the basic factor in determining the age structure of a normal population over a long period. Populations which have been characterized by broad-based age-sex pyramids (the population of India, shown above, is an excellent example of this type). On the other hand, where birth and death rates have been relatively law for some time, the age-sex pyramid is characterized by a narrow base and steep sides.

Table 2.B AGE –SEXCOMPOSITION OF INDIA: 1961

| Age group (year) | Male | | Female | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Total..... | 226,060,908 | - | 212,713,821 | - |
| 0-4..... | 225996228 | 515 | 212632190 | 48.5 |
| 5-9..... | 33176745 | 7.6 | 32905030 | 7.5 |
| 10-14..... | 33063452 | 7.5 | 31588298 | 7.2 |
| 15-19..... | 18590021 | 4.2 | 17275998 | 3.9 |
| 20-24..... | 18190157 | 4.1 | 19126173 | 4.4 |
| 25-29..... | 18524705 | 4.2 | 18042886 | 4.1 |
| 30-34..... | 15981218 | 3.6 | 14849246 | 3.4 |
| 35-39..... | 13598888 | 3.1 | 11856553 | 2.7 |
| 40-44..... | 12082312 | 2.8 | 10770047 | 2.5 |
| 45-49..... | 9773150 | 2.2 | 8320033 | 1.9 |
| 50-54..... | 9127783 | 2.1 | 7977199 | 1.8 |
| 55-59..... | 5281481 | 1.2 | 4547684 | 1.0 |
| 60-64..... | 5705175 | 1.3 | 5530815 | 1.3 |
| 65-69..... | 2471975 | 0.6 | 2378447 | 0.5 |
| 70-74..... | 2155503 | 0.5 | 2258070 | 0.5 |
| 75 and over... | 2020061 | 0.5 | 2184178 | 0.5 |
| Unknown..... | 94680 | - | 81631 | - |

Source: United Nations. Statistical Office, Demographic Yearbook, 1964. New York,1965.

Server famines leave their, mark on the age-sex pyramid by taking a higher toll of infants, young children, and the aged of both sexes than of the population in the middle years. Wars, however, reduce the male population in the young adult ages at the time of the war.

In migratory movements, young adults are generally overrepresented. Long distant migrations usually involve more males than females, while shorter movements most often draw more heavily on the female population, particularly in the Western civilizations. As a

result of migration, the young adult age groups are deflated in the "sending" population and inflate in the "receiving" population.

**Supplemental Course for Case Studies in Surveys and Censuses**

**Study Assignment**

Exercise1. What are the sex ratios in each cell of the following cross-classification for Howall in 1960? Comment on the pattern.

| Sex by race | Urbanized areas | | Other urban | Rural |
|---|---|---|---|---|
| | Central cities | Urban fringe | | |
| MALE | | | | |
| White..... | 40536 | 18586 | 21250 | 32543 |
| Negro..... | 746 | 743 | 336 | 1580 |
| Indian..... | 77 | 57 | 51 | 95 |
| Japanese..... | 53021 | 6594 | 20802 | 19718 |
| Chinese..... | 15437 | 823 | 2115 | 1194 |
| Filipino..... | 14058 | 4295 | 8878 | 17108 |
| All other..... | 25833 | 2749 | 14688 | 14220 |
| FEMALE | | | | |
| White..... | 39738 | 9973 | 20119 | 19485 |
| Negro..... | 573 | 257 | 307 | 401 |
| Indian..... | 94 | 21 | 47 | 30 |
| Japanese..... | 55798 | 6758 | 21597 | 19167 |
| Chinese..... | 14701 | 845 | 2099 | 943 |
| Filipino..... | 8019 | 2882 | 5461 | 8369 |
| All other..... | 25563 | 2559 | 14835 | 13958 |

Exercise2. The age distribution of the male population in Venezuela in 1950 and an estimate for 1964 are shown below.

(a) Distribute the "unknown" ages proportionally.

(b) Calculate the age ratios in each group from 5-9 to 60-64 for both years.

(c) Does there appear to be a marked preference for certain age groups? Comment.

| Age group (years) | 1950 | 1964 |
|---|---|---|
| All ages..... | 2482347 | 4280730 |
| 0-4..... | 415067 | 777740 |
| 5-9..... | 334560 | 633844 |
| 10-14..... | 276204 | 537230 |
| 15-19..... | 252375 | 414904 |
| 20-24..... | 237615 | 330312 |
| 25-29..... | 198196 | 300465 |
| 30-34..... | 157437 | 275823 |
| 35-39..... | 145213 | 244489 |
| 40-44..... | 114644 | 194886 |
| 45-49..... | 86936 | 163310 |
| 50-54..... | 82117 | 133297 |
| 55-59..... | 49520 | 96269 |
| 60-64..... | 50948 | 73586 |
| 65-69..... | 25894 | 48752 |
| 70 and over..... | 52220 | 55823 |
| Unknown..... | 3401 | - |

Exercise3. Refer to the age-sex pyramid for India the section 6 of this lecture. What do you think might be the cause for the difference in the length of the bars for the male and female population aged 10-14 years? Comment on other age differences.

# Lecture3. MORTALITY

## 1. INTRODUCTION

The basic measures for the study of mortality are death rates-crude death rates, age-specific death rates, etc. The idea of "risk of dying" or "probability of dying" is utilized for the construction of the life table. These probabilities in turn permit computation of the expectation of life at different ages or the proportion of the population at one age that survives to another age.

## 2. DEATH RATES

Reliable death rates depend upon the availability of reliable death registration data for the numerator and reliable population data for the denominator. Every effort should be made to evaluate the completeness of registration before interpreting the significance of the death rate.

### 2.1 Crude death rate

The crude death rate is the simplest measure of the general level of mortality in a population. It is the average number of deaths occurring during a year per 1,000 persons in the total population. It is found by dividing the total number of deaths which occurred during the year by the total population at the middle of the year, and multiplying the result by 1,000. The formula would be:

$$m=\frac{D}{P}\times 1{,}000$$

where

m= Annual crude death rate

D= Number of deaths which occurred among the population of an area during a year

P= Midyear total population of the same areas during the same year.

Crude death rates have the advantage of being simple to compute and easily understood. They can be used as broad, general measures. They have the disadvantage of being very much affected by the age structure of the population, because of the marked differences in the death rates among the various age groups. Furthermore a crude death rate

for the total population of an area conceals very different mortality rates which are usually found in different regions, among different racial, ethnic, and socio-economic groups, and in different types of areas of residence.

## 2.2 Specific death rates

Usually, it is desirable to introduce some refinements in the crude death rate, if registration is sufficiently complete to warrant the use of the data. A specific death rate may be computed for segments of the population by age, sex, race, marital status, or other characteristics provided that the data are available on both the number of persons in the population having that characteristic and the number of deaths occurring in that same group of persons.

2.2.1 Sex. The death rate of female is almost always lower than that of male for the span of life as a whole, though this is not always true for all age groups. Therefore, it is preferable to treat the two sexes separately in studying the death rates of any given area.

2.2.2 Age. Death rates differ greatly from one age to another, so that differences in age composition can seriously affect the crude death rate. Therefore, in the study of mortality, age composition should be taken into account whenever possible.



The death rate of a particular age group is referred to as an age-specific death rate. The arithmetic is exactly the same as for the crude death rate, except that only data for one age group are used:

$$m_x = \frac{Dx}{Px} \times 1{,}000$$

where

$m_x$ = Annual age-specific death rate for a population of age x

$D_x$ = Number of deaths to population in age group x in an area during a particular year

$P_x$ = Midyear population of age group x in the same area during the same year.

Age-specific death rates are usually prepared for 5-year age groups. These are fine enough to show the pattern of mortality by age, but not so detailed as to be made too erratic by errors in age reporting. In order to limit the effect of infant mortality, it is preferable to include in a table of age-specific death rates both the age groups "under 1 year" and "1 to 4 years."

The pattern of mortality by age is one of initially high rates in the first year, of life (within the first year, mortality rates are highest in the first few days of life, are very high in the first month, and decline throughout the rest of the year). After the first year the rates decline rapidly to a minimum, which usually occur around the tenth year of life. After reaching this minimum, the age-specific death rates increase gradually up to about 40 or 50 years of age, and then increase at a relatively rapid rate throughout the rest of life. Generally speaking, the decline in mortality rates in early life is quite abrupt in populations with low rates in general, and is more gradual in populations with high mortality.

The table below shows the age-specific death rates of Norway in 1955 and Mexico in 1950. As is usual in Western countries, the age-specific death rates of females are lower than those of males in all age groups except the extremely old Here also it is apparent that the differences in mortality between the two countries are greatest at the youngest ages.

It is usually desirable to make international comparisons on the basics of age-specific death rates by sex or on the basic of life table expectations of life by sex, in as much as such measurements are free of the effects of differences in age-sex composition. In the absence of life tables for a particular country, it may be possible to make use of the United Nations model life tables.

Table 3 A. AGE-SPECIFIC DEATH RATES, BY SEX, FOR NORWAY, 1955 AND MEXICO, 1950

| Age | Norway, 1955 | | | Mexico,1950 | | |
|---|---|---|---|---|---|---|
| | Both sexes | Male | Female | Both sexes | Male | Female |
| All ages..... | 8.5 | 8.7 | 8.3 | 16.2 | 17.3 | 15.2 |
| Under 1 year..... | 21.1 | 23.5 | 18.6 | 138.8 | 150.4 | 127.0 |
| 1-4 years..... | 1.3 | 1.5 | 1.1 | 27.8 | 27.5 | 28.2 |
| 5-9 years.... | 0.5 | 0.6 | 0.3 | 4.5 | 4.5 | 4.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10- 14 years... | 0.4 | 0.6 | 0.3 | 2.4 | 2.5 | 2.3 |
| 15-19 years.... | 0.7 | 1.0 | 0.4 | 3.6 | 4.1 | 3.2 |
| 20-24 years.... | 0.8 | 1.2 | 0.4 | 5.1 | 5.9 | 4.5 |
| 25-29 years... | 1.0 | 1.3 | 0.7 | 6.1 | 6.9 | 5.4 |
| 30-34 years | 1.2 | 1.5 | 0.9 | 7.2 | 8.1 | 6.4 |
| 35- 39 years.. | 1.6 | 2.0 | 1.3 | 9.1 | 10.5 | 7.8 |
| 40-44 years | 2.2 | 2.6 | 1.8 | 9.9 | 11.5 | 8.4 |
| 45-49 years | 3.2 | 3.8 | 2.7 | 12.8 | 15.0 | 10.7 |
| 50-54 years... | 5.5 | 6.9 | 4.2 | 15.3 | 17.6 | 13.1 |
| 55-59 years.. | 8.8 | 11.3 | 6.4 | 21.0 | 23.8 | 18.1 |
| 60-64 years.. | 13.6 | 16.6 | 10.8 | 28.9 | 31.7 | 26.5 |
| 65-69 years... | 22.2 | 25.7 | 19.3 | 42.8 | 44.5 | 41.1 |
| 70-74 years... | 36.4 | 41.1 | 32.7 | 62.9 | 66.0 | 60.1 |
| 75-79 years... | 63.8 | 68.5 | 60.0 | 89.1 | 89.8 | 88.5 |
| 80-84 years... | 107.8 | 110.1 | 106.1 | 120.7 | 119.4 | 121.8 |
| 85 years and over... | 218.5 | 215.8 | 220.4 | 246.8 | 229.2 | 260.6 |

Sources: United Nations. Statistical Office, Demographic Year-book,1957. New York, 1957.

**2.3 Infant mortality rates**

Because of the concentration of deaths in the first few years of life, the infant mortality rate (IMR) for deaths during the first year of life is calculated on the basis of the number of births during a year. Thus,

$$\text{IMR}=\frac{\textit{Deaths under age 1}}{\textit{Births}}\times 1{,}000$$

or, in more precise language, the infant mortality rate equals

$$\frac{\textit{Number of deaths under 1 year of age which occurred to the population of a given area during a year}}{\textit{Number of live births which occurred among the population in the same area during that same year}}\times 1{,}000$$

Strictly speaking, the infant mortality rate is not necessarily an accurate measure because the deaths, in the numerator, do not all occur to the infants born during the year, which is the population in the denominator. Many of the deaths during a calendar year are of infants born during the calendar year will die during the following year before they have

reached one year of life. However, if the number of births does not change greatly from one year to the next, these factors cancel each other to such an extent that the reliability of the infant mortality rate is not seriously impaired.

If there is much delay in birth registration, then the percentage of omissions of infant deaths is much greater than the omissions of births, because infant deaths are so concentrated in the first few days after birth. For example, in the Hispanic population of New Mexico, a 1-month delay in birth registration accompanied by failure to report either the birth or death of infants who died before attaining 1 month of age would result in omitting from the statistics 42 percent of all infant deaths (and 13 percent of all deaths) but only 3 percent of all births.

## 3. LIFE TABLES

Life tables are one of the basic tools of demographic analysis in the countries for which they are or can be made available. A life table population is the population which would exist if the age-specific death rates prevailing at some particular time were to continue throughout the life span of all the individuals, with no change in the number of births each year and no migration. That is, a life table population is a theoretical population which never has existed and never will exist in reality .It is constructed to show what the effects of mortality on a population would be if it were not being affected also by fertility and migration.

### 3.1 Nature of life tables

A life table begins with a radix of 100,000 (or 10,000, etc.) births assumed to have occurred at a single moment. This theoretical cohort is reduced at each age, according to the death rates prevailing for that age, to arrive at the number of survivors at the beginning of the next age. The death rates and the size of the initial cohort determine all the other figures in the boy of a life table.

The expectation of life at various ages and the survival ratios which may be determined, in a single step, form the survivors in each year of age or age group, are life table values of great use to demographers.

Complete life tables show all of the life table functions discussed below by single years of age. Abridged life tables usually give the life table functions by 5-year or 10 year age groups; some tables show life table functions for certain selected single years of age.

The construction of either complete or abridged life tables is a complicated process; the process ordinarily should not be undertaken unless the basic population and mortality data from which they are constructed are known to be of reasonably good quality .Even the best data must be corrected for errors of coverage and classification before being used to construct life tables. The preparation of life tables, although very important to population study, is in practice almost a field in itself and is therefore not treated fully in this discussion.

Table 3.B ABRIDGED LIFE TABLES FOR THE MALE AND FEMALE POPULATION OF A COUNTRY

| Age interval Period of life stated in years | Proportion dying... Proportion of persons alive at beginning of age interval dying during interval | of 100,000born alive | | Stationary population | | Average remaining lifetime.... Average number of years of life remaining at beginning of age interval |
|---|---|---|---|---|---|---|
| | | Number living at beginning of age interval | Number dying age interval | In the age interval | In this and all subsequent age intervals | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | $n^q_x$ | $l_x$ | $n^d_x$ | $n^L_x$ | $T_x$ | $e^o_x$ |
| MALE | | | | | | |
| 0,..... | .06660 | 100,000 | 6,660 | 95,338 | 6,153,656 | 61.5 |
| 1-4... | .02678 | 93340 | 2500 | 368360 | 6058318 | 64.9 |
| 5-9.... | .00875 | 90840 | 795 | 452210 | 5689958 | 62.6 |
| 10-14... | .00648 | 90045 | 583 | 448765 | 5237748 | 58.2 |
| 15-19... | .01064 | 89462 | 952 | 444930 | 4788983 | 53.5 |
| 20-24... | .01510 | 88510 | 1337 | 439205 | 4344053 | 49.1 |
| 25-29... | .01559 | 87173 | 1359 | 432465 | 3904848 | 44.8 |
| 30-34... | .01649 | 85814 | 1415 | 425530 | 3472383 | 40.5 |
| 35-39.. | .01922 | 84399 | 1622 | 417940 | 3046853 | 36.1 |
| 40-44.. | .02504 | 82777 | 2073 | 408700 | 2628913 | 31.8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 45-49.. | .03600 | 80704 | 2905 | 396255 | 2220213 | 27.5 |
| 50-54.. | .05265 | 77799 | 4096 | 378755 | 1823958 | 23.4 |
| 55-59 | .07685 | 73703 | 5664 | 354355 | 1445203 | 19.6 |
| 60-64.. | .11583 | 68039 | 7881 | 320490 | 1090848 | 16.0 |
| 65-69.. | .17320 | 60158 | 10419 | 274740 | 770358 | 12.8 |
| 70-74.. | .25862 | 49739 | 12864 | 216535 | 495618 | 10.0 |
| 75-79.. | .37529 | 36875 | 13839 | 149775 | 279083 | 7.6 |
| 80-84.. | .52397 | 23036 | 12070 | 85005 | 129308 | 5.6 |
| 85 and over... | 1.00000 | 10966 | 10966 | 44303 | 44303 | 4.0 |
| FEMAL | | | | | | |
| 0... | .05519 | 100000 | 5519 | 96137 | 6491157 | 64.9 |
| 1-4.. | .02424 | 94481 | 2290 | 373344 | 6395020 | 67.7 |
| 5-9... | .00777 | 92191 | 716 | 459165 | 6021676 | 65.3 |
| 10-14... | .00586 | 91475 | 536 | 456035 | 5562511 | 60.8 |
| 15-19.. | .00924 | 90939 | 840 | 452595 | 5106476 | 56.2 |
| 20-24.. | .01261 | 90099 | 1136 | 447655 | 4653881 | 51.7 |
| 25-29.. | .01355 | 88963 | 1205 | 441800 | 4206226 | 47.3 |
| 30-34... | .01491 | 87758 | 1308 | 435520 | 3764426 | 42.9 |
| 35-39.. | .01669 | 86450 | 1443 | 428640 | 3328906 | 38.5 |
| 40-44.. | .02048 | 85007 | 1741 | 420680 | 2900266 | 34.1 |
| 45-49.. | .02771 | 83266 | 2307 | 410560 | 2479586 | 29.8 |
| 50-54.. | .03891 | 80959 | 3150 | 396920 | 2069026 | 25.6 |
| 55-59.. | .05565 | 77809 | 4330 | 378220 | 1672106 | 21.5 |
| 60-64.. | .08561 | 73479 | 6291 | 351665 | 1293886 | 17.6 |
| 65-69.. | .13609 | 67188 | 9144 | 313080 | 942221 | 14.0 |
| 70-74.. | .21809 | 58044 | 12659 | 258570 | 629141 | 10.8 |
| 75-79.. | .33280 | 45385 | 15104 | 189165 | 370571 | 8.2 |
| 80-84.. | .47885 | 30281 | 14500 | 115155 | 181406 | 6.0 |
| 85 and over.... | 1.00000 | 15781 | 15781 | 66251 | 66251 | 4.2 |

Life tables are usually prepared from mortality rates based on vital statistics (for the number of deaths by age and sex) and census data (for the population by age and sex). A few

appropriate life tables have been prepared on the basis of successive censuses in countries lacking reliable death registration data by comparing the population of each age-sex group as enumerated in the later censuses. Needless to say, this method can be applied only to populations in which the effects of migration during the period concerned were negligible. Even then, a number of rather arbitrary assumptions must sometimes be made to arrive at some of the life table death rates for certain ages. Life tables have even been constructed from the results of a single census, under certain special circumstances.

Life tables are usually based on current mortality rates. Frequently the mortality rates for three successive recent years, centered on a census year, are averaged. Life tables based on current mortality rates are called current life tables, or occasionally cross-sectional tables.

A historical life table may be constructed for a particular cohort born some 75 or 85 years ago and followed through the years up to the present time. This type of life table, based on historical data about an actual cohort, is called a cohort life table or a generation life table. Such life tables are seldom constructed, since the mortality data are usually not available.

### 3.2 Abridged life tables

Table 3B illustrates an abridged life table in 5- year age groups. Each of the columns in the table presents one of the life table functions for each age group.

Column 1- Age interval. The age interval shown in column 1 is the interval between the two exact ages stated at the beginning of two consecutive groups. For example, "20-24" means the 5-year interval from the $20^{th}$ up to $25^{th}$ birthday.

Column 2- proporttion dying (${}_nq_x$). This column shows the proportion of the cohort who are alive at the beginning of an indicated age interval and who will die before reaching the end of that age interval. For example, for males 20-24 years, the proportion dying is 0.01510; this means that, out of every 1000 males alive and exactly 20 years old at the beginning of the period, 15.1 will die before reaching their $25^{th}$ birthday. In other words, the ${}_nq_x$ values represent probabilities that persons who are alive at the beginning of a specific age interval will die before reaching the beginning of the next age interval. The "proportion dying" column forms the basis of the life table; the life table is so constructed that all other columns are derived from it.

The basic formula for deriving ${}_nq_x$ from ${}_nm_x$ (age- specific death rate of the population) is as follows:

$$ {}_nq_x = \frac{2n({}_nm_x)}{2+n({}_nm_x)} $$

The ${}_nq_x$ differs from the ordinary age-specific death rate ${}_nm_x$ in that ${}_nq_x$ is based on the life table population at the beginning of the age span to which it refers whereas the ${}_nm_x$ is based on the actual population at the mid-point of that period.

Column 3-Number surviving ($l_x$). This column shows the number of persons, starting with a cohort of 100,000 live births, who survive to the exact age marking the beginning of each age interval. The $l_x$ values are computed from the ${}_nq_x$ values, which are successively applied to the remainder of the original 100,000 persons still alive at the beginning of each age interval. Thus, out of 100,000 male babies born alive, 93,340 will complete the first year of life and enter the second; 90,840 will begin the fifth year; 88,510 will reach age 20; and 10,966 will live to age 85. ($l_{x+n} = l_x - {}_nd_x$; for example, column 3 for age group 10-14 equals column 3 for age group 5-9 years minus column 4 for age group 5-9 years.)

Column 4- Number dying $-({}_nd_x)$ This column shows the number dying in each successive age interval out of 100,00 live births. Out of 100,00 males born alive, 6660 die in the first year of life, 2500 in the succeeding 4 years, 1,337 in the 5- year period between exact ages 20 and 25 and 10,966 die after reaching age 85. Each figure in column 4 is the difference between two successive figures in column 3. (Column 4 is also equivalent to column 2 × column 3.)

Column 5 and 6 – Stationary population (${}_nL_x$ and $T_x$). Suppose that a group of 100,000 individual like that assumed in column 3 and 4 is born every year and that the proportions dying in each such group in each age interval throughout the lives of the members are exactly those shown in column 2. If there were no migration and if the births were evenly distributed over the calendar year, the survivors of these births would make up what is called a stationary population- stationary because in such a population the number of persons living in any given age group would never change. When an individual left the group, either by death or by growing older and entering the next higher age group, his place would immediately be taken by someone entering from the next lower age group. Thus, a census taken at any time in such a stationary community would always show the same total

population and the same numerical distribution of that population among the various age groups. In such a stationary population supported by 100,000 annual births column 3 shows the number of persons who, each year, reach the birthday which marks the beginning of the age interval indicated in column 1, and column 4 shows the number of persons who die each year in the indicated age interval.

Column 5 shows the number of persons in the stationary population in the indicated age interval. For example, the figure given for males in the age interval 20-24 is 439,205. This means that in a stationary population of males supported by 100,00 annual births and with proportions dying in each age group always in accordance with column 2, a census taken on any data would show 439,205 persons 20 to 24 years old. For calculating column 5, the formula is:

$$5\left(\frac{l_x+l_{x+5}}{2}\right)$$

However, for the age groups 0 and 1-4, the formulas are:

$L_0 = 0.3\ l_0 + 0.7\ l_1$

$L_1 = 4(0.5\ l_1 + 0.5\ l_5)$

For the age group 85 and over, the formula is:

$$_{\infty}L_{85} = \frac{_{\infty}d_{85}}{_{\infty}m_{85}}$$

where $_{\infty}m_{85}$ is the annual age-specific death rate of the population which is the source of the table.

Column 6 shows the total number of person in the stationary population (column5) in the indicated age interval and all subsequent age intervals. For example, in the stationary population of males referred to in the last illustration, column 6 shows that there would be at any given moment a total of 4,344,053 males who have passed their 20th birthday. The total male population would be 6153656. (Column 6 = $\sum_x^{\infty} L_x$.)

Column 7- Average remaining lifetime ($e_x^0$). The average remaining lifetime (also called expectation of life) at any given age is the average number of years remaining to be lived by those surviving to that age on the basis of a given set of age- specific rates of dying. To arrive at this value, it is necessary to observe that the figures in column 5 can be

interpreted in terms of a single life table cohort without introduction the concept of the stationary population. Each figure in column 5 represents the total time (in years) lived between two indicated birthdays by all those reaching the earlier birthday among the survivors of a cohort of 100,000 live births. Thus, the figure 439,205 (column 5) for males 20-24 is the total number of years lived between the $20^{th}$ and $25^{th}$ birthdays by the 88,510 (column 3) who reach the$20^{th}$ birthday out of 100,000 males born alive.

The corresponding figure (4344053) in column 6 is the total number of years lived after attaining age 20 by the 88510 reaching that age. This number of years divided by the number of persons(4344053 divided by 88510 ) gives 49.1 years as the average remaining lifetime of males at age 20.

$$(\text{Column } 7 = \frac{column\ 6}{column\ 7}, \text{or } \frac{T_x}{l_x})$$

### 3.3 Complete life tables

Complete life tables, in which the functions are given by single years of age, are constructed in the name manner as abridged life tables, with the value of n=1. However, abridged life tables are generally constructed because most countries do not have reliable age-specific death rates by single years of age.

### 3.4 Use of life tables in population analysis

In population analysis, the expectation of life and the survival ratios are the most used values which are calculated from life tables. For convenience, death rates might be calculated from the life table and used instead of age-specific death rates, but under most circumstances this would offer no special technical advantage.

3.4.1 Expectation of life.- The expectation of life (defined in section 3.2) is the average number of years remaining to be lived by those surviving to that age. Generally, the expectation of life at birth, at age 1, or at age 10 is most useful in comparing the mortality of different population; however, for some purposes, the expectation of life at other ages may be equally useful.

Differences in mortality of different age groups must be kept in mind in interpreting expectation of life, especially when the expectation of life at birth is being used. If the average expectation of life at birth is 40 years, most of the deaths before age 40 occur in the

first few years of life; those later than age 40 are spread out more evenly but none the less increase rapidly at the older ages. A rather small proportion of deaths may occur around the fortieth year. Ordinarily the expectation of life in greater at age 1 than at age 0; a high point is reached somewhere between age 1 and age 5, after which the expectation of life declines with increasing age. Little significance should be attached to figures on expectation of life at advanced ages because of the small populations that are involved and the large age-reporting errors characteristic of those ages.

Table 3 C.EXPECTATION OF LIFE, TRINIDAD AND TOBAGO: 1900-1903 TO 1957

| Age | 1900-1903 | | 1910-1912 | | 1920-1922 | | 1930-1932 | | 1945-1947 | | 1957 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 0 year. | 36.73 | 38.75 | 38.97 | 40.95 | 37.59 | 40.11 | 44.51 | 46.95 | 52.98 | 56.03 | 59.88 | 63.35 |
| 1 years... | 43.23 | 44.81 | 44.99 | 46.73 | 43.57 | 45.82 | 50.92 | 52.34 | 57.07 | 59.46 | 63.22 | 65.87 |
| 2 years.. | 45.08 | 46.56 | 46.51 | 48.22 | 45.11 | 47.56 | 51.42 | 52.97 | 56.91 | 59.37 | 62.69 | 65.26 |
| 5 years.. | 44.65 | 45.93 | 45.54 | 47.30 | 43.87 | 46.40 | 49.56 | 51.34 | 54.54 | 56.93 | 60.14 | 62.66 |
| 10years. | 41.12 | 42.60 | 41.69 | 43.56 | 40.14 | 42.64 | 45.40 | 47.11 | 50.06 | 52.44 | 55.42 | 57.94 |
| 15 years.. | 37.29 | 38.82 | 37.73 | 39.65 | 36.09 | 38.63 | 41.04 | 42.81 | 45.50 | 47.91 | 50.78 | 53.16 |
| 20years.. | 33.63 | 35.41 | 34.12 | 36.35 | 32.34 | 35.28 | 36.97 | 39.06 | 41.20 | 43.83 | 46.15 | 48.41 |
| 25 years.. | 30.32 | 32.57 | 30.75 | 33.54 | 29.04 | 32.23 | 33.23 | 35.55 | 37.13 | 40.05 | 41.47 | 43.78 |
| 30years. | 27.09 | 29.88 | 27.46 | 30.71 | 25.82 | 29.13 | 29.48 | 32.08 | 33.10 | 36.24 | 36.86 | 39.21 |
| 35 years.. | 23.89 | 27.08 | 24.30 | 27.68 | 22.68 | 26.15 | 25.78 | 28.61 | 29.13 | 32.52 | 32.35 | 34.63 |
| 40 years.. | 20.88 | 24.06 | 21.33 | 24.65 | 19.85 | 23.37 | 22.35 | 25.16 | 25.29 | 28.70 | 27.97 | 30.21 |
| 45 years.. | 18.07 | 20.95 | 18.38 | 21.54 | 17.21 | 20.40 | 19.17 | 21.83 | 21.67 | 24.93 | 23.79 | 26.04 |
| 50 years.. | 15.46 | 17.99 | 15.59 | 18.42 | 14.66 | 17.42 | 16.13 | 18.66 | 18.34 | 21.47 | 19.72 | 21.92 |
| 55 years.. | 12.96 | 15.09 | 12.98 | 15.33 | 12.18 | 14.55 | 13.31 | 15.65 | 15.32 | 18.34 | 16.03 | 18.26 |
| 60years.. | 10.62 | 12.31 | 10.49 | 12.50 | 9.89 | 11.85 | 10.78 | 12.86 | 12.53 | 15.37 | 12.85 | 14.74 |
| 65years.. | 8.51 | 9.83 | 8.28 | 9.95 | 7.88 | 9.49 | 8.61 | 10.39 | 10.11 | 12.67 | 9.91 | 11.78 |
| 70years.. | 6.80 | 7.84 | 6.53 | 7.81 | 6.36 | 7.56 | 6.89 | 8.28 | 8.18 | 10.06 | 8.93 | 10.69 |
| 75years.. | 5.50 | 6.32 | 5.23 | 6.17 | 5.24 | 5.99 | 5.60 | 6.53 | 6.59 | 7.65 | 7.64 | 8.61 |
| 80years.. | 4.33 | 4.96 | 4.05 | 4.98 | 4.41 | 4.89 | 4.53 | 5.16 | 5.12 | 5.74 | 6.05 | 6.27 |
| 85years.. | 3.21 | 3.70 | 2.91 | 3.88 | 3.61 | 3.94 | 3.91 | 4.20 | 3.86 | 4.53 | - | - |

Source: United Nations. Statistical Office: Demographic Yearbook, 1951 and 1963. New York, 1951 and 1964 significance should be attached to figures on expectation of life at advanced ages because of the small populations that are involved and the large age-reporting errors characteristic of those ages.

It must be remembered also that the life table average expectation of life at any age assumes a continuance of the mortality rates on which the table is based. In a period of declining mortality such as the present one, it is probable that the average number of years lived by an actual group of persons now in the younger ages will be greater than the life table values for expectations of life at those ages.

Table 3.C shows the life table expectations of life for Trinidad and Tobago at different periods throughout this century. It can be seen that most of the increases in expectation of life from 1900 to 1907 was at the younger ages.

3.4.2 Survival ratios. Survival ratios based on the $l_x$ or the $_nL_x$ columns of life tables provide the easiest means of " aging" a population, a procedure which is especially important in preparing population estimates and projections. A survival ratio is the ratio of the number of persons at a certain given period of time to the number in the same group at a previous period of time; it is expressed as a decimal. For example, 5- year survival ratios may be calculate from an abridged life table based on 5 year age groups by dividing the $_nL_x$ value for each group into the $_nL_x$ value for the succeeding age group. Similarly, 10 year survival ratios may be calculated from such abridged life tables by dividing the $_nL_x$ value for the each age group into the $_nL_x$ value for the second succeeding age group. The following are $_nL_x$ values and 10-years survival ratios, $\frac{5L_{x+10}}{5L_x}$, from data for females in table 3B:

| Age Interval | $_nL_x$ | Survival ratio |
|---|---|---|
| 15-19 years | 452595 | .9761 |
| 20-24 years | 447655 | .9729 |
| 25-29 years | 441800 | .9702 |
| 30-34 years | 435520 | .9659 |
| 35-39 years | 428640 | .9578 |
| 40-44 years | 420680 | .9435 |
| 45-49 years | 410560 | .9212 |

The notation $n^{S_x}$ (see Unit III of the Atlantida Case Study on Population Data Controls) or $P_x$ (United Nations Module Life Tables ) may be used when applying a survival rate to a real population.

## 4. PRESENT TREND OF MORTALITY

Most of the increase in population in the world has been brought about by decreases in mortality rates while fertility rates remained high. In prehistoric and earlier historic periods both fertility and mortality were high. It seems probable that both the crude death rate and the crude birth rate through most of the period of history were above 40 per thousand or a little more.

The development of civilization at first brought a very slow and slight lowering of the death rates. The advent of modern medicine, increased sanitation measures, and public health programs have resulted in rapid reductions of the death rates, especially among the very young.

### 4.1 Range of crude death rates

At present, in the absence of serious under registration of deaths, the range of the crude death rate is from a low of about 6 or 7 to a high of something over 30. The upper limit of the present death rate is subject to considerable question, for the countries with the highest death rates are usually the countries with the least complete registration of deaths. It seems probable that in the recent past, death rates of 30 to 40 prevailed in most of the world. Crude death rates of 10 or less are probably temporary phenomena, occurring in countries which have had recent sharp declines in infant mortality and which consequently have an unusually large percentage of population in the younger age groups in which mortality is at its lowest.

Even thought relatively little faith can be placed in the precise figure given for the crude death rate of many countries, it is clear that the highest death rates in the world occur in the indigenous populations of Africa, and that these are followed closely by the death rates now prevailing in parts of Asia and Latin America. The lowest rates are to be found in Europe, Anglo America, Australia, and New Zealand. A worldwide decline in mortality is apparent from the crude death rates, even though the completeness of death registration in most countries of the world has increased in recent years.

## 4.2 Trend in infant mortality

The infant mortality rate now ranges from less than 20 in a few countries which have enjoyed unusually good health conditions eor a prolonged period, to well over 200 in some aboriginal populations. a more normal range at the present time seems to be from about 20 to about 100.

## 4.3 Trend in life expectancy

The average expectation of life at birth ranges from about 25 years, or possibly a little lower in some aboriginal tribes, to about 75 years in some countries of Europe and North. Low expectancies occur in Africa, and parts of Asia, and Latin America.

## Study Assignment

Problem A: The estimated population and the reported number of deaths for Trinidad and Tobago in 1955 are shown below.(Because of rounding, totals are not always the sum of parts.)

| Age | Population | | | Number of deaths | | | Age-specific death rate | |
|---|---|---|---|---|---|---|---|---|
| | Both sexes | Male | Female | Both sexes | Male | Female | Male | Female |
| All age.... | 720800 | 361450 | 359400 | 7462 | 4028 | 3434 | | |
| Under 1 year... | 30000 | 15250 | 14750 | 2052 | 1176 | 876 | | |
| 1-4 years... | 87750 | 44250 | 43500 | 354 | 197 | 157 | | |
| 5-9 years... | 99150 | 50300 | 48850 | 90 | 43 | 47 | | |
| 10-14 years... | 81900 | 41150 | 40750 | 63 | 26 | 37 | | |
| 15-19 years... | 62000 | 31200 | 30850 | 113 | 58 | 55 | | |
| 20-24 years... | 53300 | 26150 | 27150 | 138 | 62 | 76 | | |
| 25-29 years... | 51350 | 25050 | 26300 | 153 | 71 | 82 | | |
| 30-34 years... | 48150 | 24050 | 24100 | 178 | 82 | 96 | | |
| 35-39 years... | 44900 | 22700 | 22250 | 205 | 98 | 107 | | |
| 40-44 years... | 39650 | 20150 | 19500 | 264 | 143 | 121 | | |
| 45-49 years... | 34100 | 17500 | 16600 | 337 | 193 | 144 | | |
| 50-54 years.. | 27150 | 14000 | 13150 | 386 | 209 | 177 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 55-59 years.. | 20300 | 10250 | 10050 | 410 | 267 | 143 |
| 60-64 years.. | 13950 | 7200 | 6750 | 436 | 248 | 188 |
| 65-69 years… | 9900 | 4950 | 4950 | 712 | 390 | 322 |
| 70-74 years | 8150 | 3700 | 4450 | 535 | 304 | 231 |
| 75-79 years.. | 5500 | 2250 | 3250 | 402 | 220 | 181 |
| 80-84 years.. | 2450 | 1000 | 1450 | 294 | 129 | 165 |
| 85 and over… | 1100 | 400 | 700 | 340 | 111 | 229 |

Exercise1. Calculate the crude death rate by sex.

Exercises 2. Assuming 33000 births in 1955, calculate the infant mortality rate (children under 1 year).

Exercise3. Calculate the age-specific death rates by sex.

**Supplemental Course for Case Studies in Surveys and Censuses**

Problem B: The following is a portion of a life table for a country for a recent year, with some of the cells already filled.

| Age interval ..... Period of life stated in years | Proportion dying... Proportion of persons alive at beginning of age interval dying during interval | of 100,000 born alive | | Stationary population | | Average remaining lifetime.... Average number of years of life remaining at beginning of age interval | Surv-ival ratio |
|---|---|---|---|---|---|---|---|
| | | Number living at beginning of age interval | Numbe r dying during age interval | In the age interval | In this and all subsequ-ent age intervals | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | $n^q_x$ | $l_x$ | $n^d_x$ | $n^L_x$ | $T_x$ | $e^o_x$ | |
| MALE | | | | | | | |
| 0..... | .02470 | 100000 | 2470 | 98271 | | | |
| 1-4... | .00386 | 97530 | 376 | 389.368 | | | |
| 5-9.... | .00222 | 97154 | 216 | 485230 | | | |
| 10-14... | .00218 | | | | | | |
| 15-19... | .00474 | | | | | | |
| 20-24... | .00630 | | | | | | |
| 25-29... | .00667 | | | | | | |
| 30-34... | .00853 | | | | | | |
| 35-39.. | .01200 | | | | | | |
| 40-44.. | .01837 | | | | | | |
| 45-49.. | .02844 | | | | | | |
| 50-54.. | .04472 | | | | | | |
| 55-59 | .06699 | | | | | | |
| 60-64.. | .09857 | | | | | | |
| 65-69.. | .14644 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 70-74.. | .20442 | | | | | | |
| 75-79.. | .29100 | | | | | | |
| 80-84.. | .42208 | | | | | | |
| 85 and over. | 1.00000 | 19848 | 19848 | | | | |

Exercise1. Complete the cells in the table. Assume that the value of $\infty^{m_{\theta s}}$ is 235 per 1000 for the population that is the source for this table.

Exercise2. At what age would the original cohort of 1000000 have been reduced by half?

Exercise3. What is the probability that one will live to reach age 1? Age20?

Exercise4. Calculate the 10 year survival ratio for each age group.

# Lecture 4. FETILITY

## 1. INTRODUCTION

Fertility concerns the addition of new members to a population by birth; that is, the actual performance of a population in bearing children. It is not to be confused with fecundity, the biological capacity of the population to bear children.

Fertility, mortality, and migration are the three processes which may act to change the size or composition of a population. The first of these is probably of greater significance in the industrialized nations than the other two. Whereas mortality rates appear to have fluctuated widely in area and through time in centuries past, and to have been the major factor in changing rates of population growth, they are today comparatively low and stable in many countries. The fertility rates, on the other hand, were probably high and relatively stable throughout the world until a few decades ago. Today, they vary greatly among different countries.

Several types of data are used by demographers to study fertility. Vital statistics systems and population censuses provide most of these data. Special sources, such as baptismal records, may prove valuable either for basic data or for the evaluation of birth registration or census data under some circumstances.

## 2. EVALUATION OF BIRTH REGISTRATION DATA

Most countries maintain a birth registration system from which statistics are periodically compiled (see Lecture 1). However, birth registration is so incomplete in many countries that the data cannot be used for statistical purposes. Before relying heavily on birth registration data for the measurement of fertility, every effort must be made to determine the completeness of registration. If evidence of gross omission is found by comparing registration data with the infant population enumerated in a census or with baptismal records or other sources, or simply by arriving at a crude birth rate which seems impossibly low under certain circumstances, there is little point in going through a highly refined fertility analysis.

A preliminary evaluation may be accomplished fairly rapidly by comparing the number of infants enumerated in the census with the number of births reported in the year preceding the census (while taking into account that the infants enumerated are the survivors of those

births).If this check indicates that birth registration data are grossly deficient, it may be necessary to estimate birth from census data on infants and young children. Analytical devices which rely upon registration data alone, without making use of census data or population estimates, should be approached with caution. The safest assumption is that deficiencies in the registration do not occur in the same degree in all segments of the population.

**2.1 Infant population estimated from vital statistics**

Persons born during the 12 months preceding a census who were still alive on the census date should be reported as children under 1 year of age in the census data. The number of surviving infants at the date of the census according to vital registration may be arrived at by deducting an allowance for infant mortality from the number of registered births. The United Nations has made a number of comparisons of the type under discussion by deducting 70 percent of the infant deaths which occurred in the year before the census from the number of registered births. Not all of the registered infant deaths should be deducted because some of those deaths involved infants born during the preceding year, and because only those infants born at the first of the year preceding the census have suffered the full impact of infant mortality.

If birth registration is essentially complete, it may well be found that the number of surviving infants estimated in this way is greater than the number of infants enumerated in the census. Such a finding could be due to the under enumeration of infants in the census;; it would not constitute conclusive evidence that birth registration is complete.

The only definite conclusion which may be arrived at by means of this comparison is that the reported number of registered births is probably incomplete by at least the number by which the infant population enumerated in the census exceeds the registered infant population.

If the birth registration data stand up under this test, it does not mean that other tests can be omitted. On the contrary, it simply indicates that it would be worthwhile to perform such other tests as may be practical in the hope that they, too, will fall to confirm the hypothesis that birth registration data are deficient.

### 2.2 Effects of delayed registration

The delay of birth registration may affect the quality of data on the number of births. It is often the case that a baby dies before his birth is registered and neither the birth nor the death is registered. Even though all surviving babies may be registered by the time they are 1 or 2 years old; the practice of delayed registration of births is likely to result in some understatement of the number of births in the statistics especially if infant mortality high. Such errors in birth registration data are ordinarily small enough so that, if registration is otherwise essentially complete, appropriate adjustments can be made on the bases of data on the basis of data on the age of babies at the time their births were registered.

## 3. Birth Rates

Birth rates are expressed in several times, including the crude birth rate, age-specific birth rates, and parity-specific birth rates, defined below.

### 3.1 Crude birth rate

The number of births per 1,000 inhabitants, known as the crude birth rate, is the simplest measure of the rate at which a population is being replenished by births. It is arrived at by dividing the number of live births which occurred in one year by the number of inhabitants in the same population at the midpoint of that year, and multiplying the result by 1,000. That is,

$$\text{Annual crude birth rate} = \frac{\textit{Number of live births in an area duri ng a year}}{\textit{Midyear total population in the same area in the same year}} \times 1{,}000.$$

Only live births should be used in the numerator; the denominator should include all of ( but more than ) the population in which the births occur. This last point is especially important in arriving at birth rates for areas less than entire nations. It is even more important when comparing rural with urban areas than when comparing larger territorial divisions with each other. Births are ordinarily reported first on the basis of place of occurrence, which often is different from the usual place of residence of the mother. Whenever possible, data on births classified by place of residence of the mother should be used. If such data are not available, rural urban comparisons should not be made because varying numbers of births to rural mothers occur in urban hospitals.

It is usually preferable to treat each ethnic group un the rural and in the urban population separately in analyses if the data permit. Otherwise, the pronounced rural urban fertility differentials which exist in many countries may be mistaken for inter-ethnic or other differentials.

In the absence of errors in the reporting of the number of births or errors in the population base, the crude live birth rates range from about 15 (in the low-fertility countries of Europe) to approximately 50, or even higher, in the areas of highest fertility.

The crude birth rate is not a sufficiently refined measure of fertility for some purposes. In studying fertility differentials, the population analyst not only wants to know that country A has a relatively larger number of babies per 1,000 population than country B, but he also needs to know the various factors that contribute to this difference. For example, in preparing estimates of future fertility for population projections, the analyst should know as much as possible about past and present population variables that affect fertility; the determination and analysis of these factors require a more refined measure than that offered by the crude birth rate. Nevertheless, the crude birth rate is a powerful measure for determining the impact of present fertility on the total population; but it should be used only as a measure of the overall fertility.

### 3.2 General fertility rate

Statistically, the birth rate is a measurement of the probability, or the "risk," of giving birth to a living child. Obviously, it is not the total population that is "at risk," but the female population of child-bearing age. Consequently, differences in the crude birth rate may indicate nothing more than differences in the percentage of the population made up of women in the childbearing ages. The general fertility rate is the number of live births per 1,000 women in the child bearing ages. Most demographers use the female population 15 to 44 or 15 to 49 years old as the base of this rate. The United Nations recommends that the ages 10 to 49 be used as the base. The general fertility rate is given by the following formula :

$$\text{General fertility rate} = \frac{\textit{Number of live births in an area during ayear}}{\textit{Midyear female population aged 15–44 in same area in same year}} \times 1{,}000$$

If virtually all births occur within marriage (including consensual union) in the society under study, a further refinement may be introduced by limiting the denominator to females in the childbearing ages who are either married or living in consensual unions. Such

refinement puts this rate into clearer focus because if eliminates from the denominator (which comprises females 15 to 49 years old) all those women who are unmarried, divorced, or widowed. This rate might appropriately be referred to as the marital a status – general fertility rate to distinguish it from the more common general fertility rate.

Either the general fertility rate or the marital-status-general fertility rate might also be calculated on the basis of the male population from 15 to 59 years of age, in which case the name of the rate would be preceded by the word "male"

### 3.3 Age –specific birth rates

Age specific birth rates differ from the general fertility rate in that both the numerator and the denominator are restricted and the age span is shortened. Most commonly, age specific rates are calculated either for 5-year age groups or by single years of age. The numerator is the number of live births to females of a specified age; the denominator is the number of women of that age.

$$\text{Annual age-specific} = \frac{\text{Number of live births to females of a specified age in an area during a year}}{\text{Midyear female population of the same specified age in same area and same year}} \times 1{,}000$$

Table 4 A. AGE-SPECIFIC BIRTH RATES: UNITED STATES, 1936 AND 1950,

AND PANAMA AND PUERTO RICO, 1950

| Age group | United States | | Panama, 1950 | Puerto Rico,1950 |
|---|---|---|---|---|
| | 1936 | 1950 | | |
| All ages*..... | 52.5 | 80.3 | 114.2 | 135.0 |
| 10-14 years**... | 0.5 | 0.9 | 1.4 | 0.4 |
| 15-19 years..... | 45.1 | 79.4 | 123.6 | 99.2 |
| 20-24 years.... | 116.2 | 193.6 | 244.2 | 279.7 |
| 25-29 years.... | 105.0 | 163.3 | 211.3 | 260.3 |
| 30-34 years.... | 71.4 | 101.3 | 139.3 | 200.0 |
| 35-39 years.... | 45.7 | 51.2 | 82.1 | 143.1 |
| 40-44 years.... | 16.0 | 14.5 | 26.2 | 53.1 |
| 45-49 years***.. | 1.8 | 1.1 | 8.3 | 11.7 |

Rates based on live births to women of all ages but computed on the female population aged 10 to 49 years.

Rates based on live births to women under 15 years of age but computed on the female population aged 10 to 14 years.

Rates based on live births to women aged 45 and over but computed on the female population aged 45 to 49 years.

Source of data: United Nations Statistical Office. Demographic Yearbook, 1954, New York, 1954.

Table 4A shows the age-specific birth rates for the United States in 1936 and 1950, and for the United States in 1936 and 1950, and for Puerto Rico and Panama in 1950.Note that the relative differences between the 1950 rates for Panama and Puerto Rico on the one hand, and the United States on the other, are smallest in the ages of highest fertility and greater of the older ages. However, the relative increases in fertility in the United States between 1936 and 1950 were greatest in the ages of highest fertility and at ages below, but were relatively small among older women. Comparison of the United States with the two other countries shows that the differences in fertility for "all ages" in 1950 are due to differences in fertility in each of the age groups, especially after age 35, whereas the differences between 1936 and 1950 in the United States was due principally to a change in the fertility of women from 15 to 34 years of age.

Age-specific birth rates can be further refined in the same manner as the general fertility rate. This refinement can be accomplished by limiting the base population to those women who are living as married.

### 3.4 Parity-specific birth rates

Parity-specific birth rates relate the number of births by birth order (that is, the first birth to a woman, the second birth to the same woman, etc.) to the number of women who have already borne enough children to be "at risk" of bearing a child of the specified order. For example, the second-party birth rate is the number of second births per1,000 women who have already had one child.

$$\text{Annual parity specific birth rate} = \frac{\begin{array}{c}\text{Number of births of agiven}\\ \text{birh order occuring}\\ \text{in an area during a year}\end{array}}{\begin{array}{c}\text{Midyear female population of appropriate}\\ \text{parity group in same year}\end{array}} \times 1000$$

Parity-specific birth rates may also be made specific for age of mother.

Sufficiently detailed data are rarely available for the computation of parity-specific birth rates by age, however, because corresponding population figures are not available except at the census period, and specific questions on number of children ever borne would have to be asked of the female population. Therefore, the birth rate for birth order is usually calculated simply on the total female population aged 10 to 49. Rates computed in this manner are usually satisfactory for comparisons from one year to another in the same population, and for crude comparison of different populations.

### 3.5 Gross reproduction rate

The gross reproduction rate is the number of girl babies that would be produced by the average woman who survived the entire reproductive period and who experienced the age-specific birth rates prevailing at the time by for which the rate is calculated. It is calculated by adding together the age specific birth rates of female births for all age groups, and converting the result to a rate " per woman" by dividing by 1,000. That is, the gross reproduction rate is the sum of the age-specific birth rates, using only female births for the calculation of the rates.

In practice, the gross reproduction rate is usually calculated from data for both male and female births, and from age-specific birth rates for five-year age groups. When this is done, the age-specific birth rates for5-year age groups are added together and the total is multiplied by five (because there are only one-fifth as many rates as there would be if single-year age-specific birth rates were used). The product is then divided by 2.05 (because the "normal" sex ratio at birth is about 105 males per 100 females in most populations) to arrive at the gross reproduction rate. This procedure is illustrated below.

| Age of mother (years) | Number of Recorded births | Enumerated female Population | Age-specific birth Rate per woman |
|---|---|---|---|
| 10-14..... | 90 | 156,362 | 0.00057 |
| 15-19..... | 12,634 | 156,319 | 0.08082 |
| 20-24..... | 20,046 | 141,711 | 0.14145 |
| 25-29..... | 16,214 | 109,844 | 0.14760 |
| 30-34..... | 10,043 | 78,469 | 0.12798 |
| 35-39..... | 7,586 | 77,753 | 0.09756 |
| 40-44..... | 2,618 | 60,875 | 0.0300 |
| 45-49..... | 910 | 51,369 | 0.01771 |

**In this illustration, the gross reproduction rate is equal to...**

$$\frac{(sum\ of\ age\text{-}specific\ birth\ rates)\times 5}{2.05} = \frac{0.65669\times 5}{2.05}$$

$$= 1.06.$$

**The gross reproduction rate is a single-figure summary of all the age-specific birth rates of a population, free from the influence of age composition. As such, it is a convenient means for comparing fertility performance independently of the effects of differences in age composition at different times or for different areas, provided reliable data are available: However, as is the case with all rates based on birth registration data, one often encounters cases in which large differences in the rate reflect differences in the completeness of birth reporting rather than true differences in fertility.**

**The gross reproduction rate can be calculated using the birth rates according to the ages of men in the population, though this type of rate is seldom used. However, if the births are to be male births only, then we have a rate which may be called the "male gross reproduction rate".**

### 3.6 Net reproduction rate

**The gross reproduction rate does not take into account the effects of mortality on population replacement by fertility; it simply indicates the average number of girl babies that would be born to a member of a cohort of women. Obviously, some women die before they**

have completed the child-bearing period; some, of course, die before the period begins. The net reproduction rate takes this into account. This rate is the average number of girl babies that would be born to each woman in a cohort of women taking into account deaths among the new cohort of women throughout the child-bearing ages, using the age-specific death rates prevailing at a given time.

The net reproduction rate is calculated by multiplying the survival rate of each age as given in a life table (see Lecture 3) by the age-specific birth rate for that age (taking into account only female births) and adding the products of the multiplication.

The example below illustrates the calculation of the net reproduction rate.

| Age (year) | Age-specific Birth rate Per woman | Female survival Rate from birth to middle of Age group | Expected survived births per woman (column 2× colum3) |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 10-14.... | 0.00057 | 0.83440 | 0.00048 |
| 15-19.... | 0.08082 | 0.81607 | 0.06595 |
| 20-24.... | 0.1415 | 0.78971 | 0.11170 |
| 25-29..... | 0.14760 | 0.76080 | 0.11229 |
| 30-34.... | 0.12798 | 0.73163 | 0.09363 |
| 35-39.... | 0.09756 | 0.70219 | 0.06851 |
| 40-44.... | 0.04300 | 0.67220 | 0.02890 |
| 45-49 | 0.01771 | 0.64161 | 0.01136 |

In this illustration, the net reproduction rate is equal to-

$$\frac{(sum\ of\ expected\ births\ per\ woman) \times 5}{2.05} = \frac{0.49282 \times 5}{2.05}$$

$$= 1.20$$

The net reproduction rate is thus 11.20 in this example, which means that if birth and death rates of that year continued, each 100 women in the child-bearing ages would have 120 daughters who would survive to those same ages.

A net reproduction rate of 1.00 means, in theory, exact replacement of the population; that is, on the average, each woman who reaches the child-bearing ages succeeds in raising one daughter who survives to the child-bearing ages.

The net reproduction rate has come to be used more cautiously in recent years. If rates change greatly from one year to the next, then it cannot be used as a prediction of population increase. Also, the net reproduction rate requires reliable death registration statistics as well as reliable birth registration data and accurate census enumeration by age.

Obviously, the net reproduction rate is a smaller number than the gross reproduction rate. The greater the mortality of females, the greater will be the difference between these two rates. In the example above, the gross reproduction rate (the reproduction rate if all the female infants born survived to the child-bearing ages) is 1.60 instead of 1.20.

## 4. CENSUS DATA ON FERTILITY

Birth registration data are too incomplete to be much value for fertility analysis in many parts of the world. Even in countries where birth registration is relatively complete, differentials in the completeness of birth registration make it somewhat risky to use rates dependent upon birth registration data for anything but gross comparisons. In some countries, the quality of the data is such that birth rates cannot even be used with safety to detect major differences in fertility.

Census data are also subject to errors; however, while these errors may change the counts considerably, many of them cancel each other in such a way that the rates constructed from the counts are affected relatively little. For this reason, measurements of fertility based on census data alone may sometimes be more reliable than those based on vital statistics, in some areas.

### 4.1 Child-woman ratio (fertility ratio)

The child – woman ratio, or fertility ratio, is the number of children under 5 years old per 100 woman 15 to 44 years of age, both as enumerated in a census. The ratio is calculated as follows:

$$\text{Child-woman ratio} = \frac{childern\ under\ 5}{woman\ 15\ to\ 44} \times 100$$

The principal advantage of the child-woman ration is that it can be derived from any census giving the population by age and sex. It requires no birth registration data; it requires no census data on the number of children ever born; and it requires no special tabulations of any sort.

The child-woman ratio is influenced by cover age errors and by age reporting errors. Little research has been done to determine the extent to which such errors may affect the child-woman ratio. Where a large percentage of the population in the first years of life is omitted from the census (as is frequently the case), the child-woman ratio may be seriously affected unless net omissions are proportionately as large in the female population 15 to 44 years old as among children under 5. These errors may cancel each other to a considerable extent. In any case, they are likely to be smaller than corresponding omissions from birth statistics.

The child-woman ratio does not have a "proportional" relationship to the crude birth rate because (a) it is influenced to a greater extent by infant and childhood mortality rates, and thus tends to measure fertility more effectively, and (b) it is independent of gross errors in the total population count, although it may be influenced somewhat by large errors in the female population aged 15 to 44 years. The extreme range of the child-woman ratio is from about 30 to about 80.

In using the child-woman ratio, extreme care must be taken to make sure that mothers and their children are classified in the same group. For example, the child-woman ratio of foreign-born women relates to the foreign-born and native-born children of these women; the child-woman ratio of foreign-born women after they have migrated relate only to the native-born children of these women.

### 4.2 Number of children ever born

Many recent censuses have included a question on the number of children ever born to enumerated women in certain groups. In some countries this question has been asked for all women or for all women over a certain age (such as 12 years); in others, it has been asked only for women who have been married. Generally, the question asks for the number of children born alive to each woman up to the date of the census.

Census data on the number eve born can be used in a variety of ways as substitutes for birth registration data. Such data are classified in the wrong group by urban-rural residence, then their mothers are also classified in the same wrong group, and (b) if large numbers of children are omitted, their mothers are also likely to be omitted. Responses to the question on the number of children ever born are probably subject to some memory bias, however; this is especially true of responses for older women, and particularly in reporting children who have already died.

The most frequent used made of the tabulations on number of children ever born is for showing the proportions of women having had various numbers of children. This is particularly useful if the information is available for successive censuses. An increase in the total number of children per woman from one census to the next may result from larger numbers of women having two or three children each, even though fewer women have seven or sight each.

A common measure of fertility is the ratio of total number of children ever born to the women in an age group that has completed its childbearing; that is, 45 to 49, or 50 to 54 years of age. This gives the actual performance in the past of a particular cohort that has completed its fertility, or the "average size of completed family."

## 5. PRESENT TRENDS OF FERTILITY

Fertility has been high in most of the world during most of history, and is still high in most of the world. Very high fertility means, as a rule, a crude birth rate of 50 per thousand or higher, and an average of about 6 children to each woman who lives to the end of the reproductive period.

Comparative data on births in the various regions of the world are misleading, because many of the countries with the highest fertility also have the least complete registration of births. Many of the figures presented on the number of births cannot be accepted as even indicative of the true fertility of the population. Child-woman ratios (fertility ratios) from census data are a more reliable measure of fertility in many areas of the world.

In general, the picture is one of relatively low fertility in Western Europe, the United States, Canada, New Zealand, and Australia, and of very high fertility in Africa, much of Asia, and most of Latin America.

Where there have been declines in mortality, they have usually been followed by declines in fertility, but not until after a period of years. The intervening period, of lowered mortality but still high fertility, in a period of rapid population growth.

Fertility is usually lower in urban-industrial areas than agricultural societies. Even in highly industrialization countries, fertility is higher in rural areas; and even in primarily agricultural countries fertility is lower in the cities. Until quite recently, fertility steadily and consistently declined with increasing industrialization and rising standards of living. Since World War II, there have been widespread increases in the birth rates in the industrialized nations; more recently, however, birth rates have being declining.

## Study Assignment

Exercise1. From the data given below, calculate the

(a) General fertility rate

(b) Age- specific birth rates

(c) Gross reproduction rate (using 1.05 as the sex ratio at birth)

(d) Net reproduction rate (using 1.05 as the sex ratio at birth)

| Age group (1) | Number of births (2) | Female Population (3) | Age specific Birth rate (4) | Female survival rate from birth to middle of age group (5) | Expected survived births per woman (6) |
|---|---|---|---|---|---|
| 10-14 years... | 40 | 48,600 | | 0.84000 | |
| 15-19 years... | 4,480 | 43,800 | | 0.83250 | |
| 20-24 years... | 12,060 | 39,400 | | 0.82100 | |
| 25-29 years... | 10,310 | 30,500 | | 0.80570 | |
| 30-34 years... | 6,430 | 23,700 | | 0.78600 | |
| 35-39 years... | 4,630 | 22,900 | | 0.76500 | |
| 40-44 years | 1,560 | 18,100 | | 0.74000 | |
| 45-49 years | 220 | 14,000 | | 0.70990 | |

## GLOSSARY OF TERMS

*Abridged life table:* A life table covering the full range of life, with life table functions presented for age groups rather than single years of age (Lecture 3).

*Age ratio:* The ratio of an enumerated age group to the average of the two adjacent age groups (Lecture 2 ).

*Age- sex pyramid:* Age distribution by sex, graphically represented as a bar chart (Lecture 2 ).

*Age-specific birth rate:* A measure expressing number of births per 1000 women of specified age (Lecture 4).

*Age-specific death rate:* A measure expressing the number of deaths per 1000 population of specified age (Lecture3).

*Birth rate:* A measure expressing the number of births in relation to the size of the population from which these births arose (Lecture4).

*Child-woman ratio:* Number of children under 5 years old per 1000 women 15 to 44 years of age at a certain point in time (Lecture 4).

*Cohort:* In demographic analysis this term refers to a group of persons having in common a demographic experience or change of demographic status or classification during the same period of time.

*Cohort-component projection:* A form of population projection in which the population at a future data is computed separately for each age cohort of the population by taking into account the change in the size of each cohort resulting from births, deaths, and migration. The base of such a computation is a set of figures representing the distribution of the population by age and sex at a given date. The projected size of cohorts included in the base is affected only by death and migration, whereas the projected size of cohorts born after the base date is also affected by the number of births in each time period between the base date and the date to which the projection applies (Lecture 5).

*Component projection:* A method of projection in which the projected population is computed by adding or subtracting from a base population the number of births, deaths and migrants estimated to occur during the projection period. Whenever the computation is done

separately for each age cohort of the population, it is called a cohort-component projection (Lecture5).

*Crude birth rate:* The ratio of the number of births to the total population during a period of time, usually a year. It is generally expressed as deaths per 1000 total population. It is computed by dividing the number of births during a period of time by the population at the midpoint of that period, and multiplying by 1000(Lecture 3).

*Crude death rate;* The ratio of the number of deaths to the total population during a period of time, usually a year, It is generally expressed as deaths per 1000 total population. It is computed by dividing the number of deaths during a period by the population at the midpoint of that period, and multiplying by 1000 (Lecture3).

*Death rate:* A measure expressing the number of deaths in relation to the size of the population in which these deaths occurred (Lecture3).

*Expectation of life:* A measure (base upon a life table) of the expected average future life time (in years) of persons at a specified age. Conceptually, it equals the number of years of life remaining to all persons reaching a specified age in a life table, divided by the number of persons reaching that age (Lecture3).

*Expectation of life at birth:* A measure (based upon a life table) of the expected average length of the expected average length of life of a birth cohort. Conceptually, it equals the number of years of life remaining at birth divided by the radix of that life table (Lecture3).

*Extrapolation:* Any mathematical process for estimating the value of a variable at points outside an interval for which known values of the variable exist. For example, if the population of a country is known as of 1 January 1965, and 1 January 1966, a mathematical computation which uses the known figures for the two dates to estimate the population as of 1 July 1966 is called extrapolation (Lecture 5).

*Fertility ratio:* See Child-woman ratio,

*General fertility rate:* The number of children born during a year per 1000 women of childbearing age at the midpoint of the year. The most common definition of childbearing age for purpose of computing the fertility rate is the age range from 15 to 44 years, although other age ranges may be used if advantageous for particular purposes. The general fertility rate has sometimes been referred to as the age-limited birth rate (Lecture 4).

*Cross reproduction rate:* Average number of girl babies that would be born to each woman in a cohort of women subjected to the age-specific birth rates prevailing at a given time (Lecture 4).

*Infant mortality: Mortality prior to age 1 (Lecture3).*

*Infant mortality rate*: A measure of infant mortality expressed as the number of infant deaths during a year per 1000 live births during that same year. It should be noted that some of the infant deaths in the numerator of the infant mortality rate occur to infant born in the year prfor to that for which the infant death rate is computed. Hence, the measure is only an approximation of the true risk of mortality during the year of birth (Lecture3).

*Interpolation:* Any mathematical process for estimating the value of a variable at points intermediate between two or more known values of the variable. For example, if the population of a place is known as of 1 January 1940, 1 January 1950, and 1 January 1960, a computation using the last two or all three of the known values to estimate the population on 1 July 1953 would be called interpolation (Lecture 5).

*Life expectancy:* See Expectation of life

*Life table:* A tabular numerical representation of mortality and survivorship of a cohort of births at each age of life. The conventional life table is based on the assumption that as the cohort passes through life it experiences mortality at each age in accordance with a predetermined pattern of mortality rates which do not change from year to year. The life table thus constitutes a hypothetical model of mortality, and even though it is usually based upon death rates from a real population during a particular period of time, it does not describe the real mortality which characterizes a cohort as it ages. There is another kind of life table in which the mortality patterns are derived from the experience of the same cohorts as they pass through different ages. Such tables are called "Cohort life tables" or "Generation life tables." Because many years must pass to accumulate the information needed to construct a cohort life table, such tables are rare. Due to differences in mortality patterns between men and women at different ages, life tables generally are constructed separately for each sex. The life table is a very useful tool for computing estimates of the mortality component of population change. This is done by the use of specific figures from the entire array which comprises the life table. The information in this array of figures is of several different types, each of which is called a life table function (Lecture3).

*Life table functions:* Each column of figures in the array which comprises a life table has a precisely defined meaning. Each expresses some significant feature of the cohort which the life table portrays. Since all the number in the life table relate to the original cohort, it is convenient to deal with a birth cohort of standard size, usually 100000 or 10000 or even 1000. This is called the radix of the life table (Lecture3).

*Migration:* The movement of people from one area to another involving a change of residence and not merely transitory travel. When the movement is between countries it is called international or foreign migration: when it is within a country it is called internal migration. Internal migrants are called out-migrants with reference to the area from which they depart and in-migrants with reference to the area to which they come. The numerical difference between in-migration and out-migration is called net migration and represents the net change in the population of an area resulting directly from migration (Lecture1).

*Natural increase:* The excess of births over deaths. When deaths exceed births there is what may be called a negative natural increase.

*Net reproduction rate:* Average number of girl babies that would be born to each woman in a cohort of woman subjected to the age-specific birth and death rates prevailing at a given time (Lecture4).

*Parity-specific birth rate:* Birth rate relating the number of births of specified birth order to the number of women who have borne one child less than the number indicated by the specified by the specified birth order (Lecture4).

*Radix;* The size of the birth cohort of a life table. For convenience, it is most commonly set at 100000, 10000 or 1000 (Lecture3).

*Rate of population change:* A relative measure of population change defined as the change in population during a period divided by the population at the beginning of the period (Lecture1).

*Registered birth:* A birth which has been official recorded in some form of civil register and which is included in the birth statistics. Statistics of registered births are sometimes complied by area of occurrence of the birth and sometimes by area of residence of the mother. The two are not necessarily the same. Also, some births are registered in a time period after they occur

and may be included in the totals for the period of registration rather than those for the period of birth. Sometimes, there are births which are not registered (Lecture 1 and 4).

Registered death: A death which has been officially recorded in some form of civil register and which is included in the death statistics. As is the case in birth registration, registered deaths may be tabulated by place of occurrence, or period of registration (Lecture1).

Sex ratio: The number of males per 100 females in a population. The sex ratio may be computed for the total population, for specific age groups, for persons born during a specified period, for persons dying during a specified period, and for other subgroups of the total population (Lecture2).

*Specific death rate:* Death rate computed for a specific segment of the population (Lecture3).

*Stationary population:* A population "closed" to migration having the same number of births as deaths over a given period of time, usually one year: for example a population with a natural increase of zero- the Life Table population (Lecture3).

*Survival ratio:* The proportion of a cohort which survives from one age to an older age. When taken from a life table it is called a "life table survival rate" (Lecture3).

*Survivors:* Those members of a cohort at data who are still alive after the passage of a specified period of time. For certain demographic computations it is useful to distinguish different classes of survivors, such as survivors of births or survivors of migrants (Lecture3).

Under enumeration: Incompleteness of coverage in a census or survey. It is usually expressed as a percentage of what should have been the complete count rather than as a percentage of the number of persons enumerated (Lecture2).

Under registration: Incompleteness of registration of vital events (Lecture1).

# DEMOGRAPHIC STUDIES

# 8.0 DEMOGRAPHIC ANTHROPOLOGY*

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## Learning Objectives

After reading this Unit, you would be able to:

- Define demographic anthropology;
- Understand the scope and relationship of demographic anthropology with other allied disciplines; and
- Explain the sources of demographic data and the process of demographic changes.

## 8.0 INTRODUCTION

Demography is the systematic study of the size, distribution and composition of human population, and their changes resulting from fertility, mortality, and migration (*Poston* and *Bouvier*, 2010). The term demography is derived from two Greek words 'demos' means population and 'graphia' means description or writing. The term was first used in 1855 by Belgian statistician Achille Guillard. Anthropological demography uses anthropological theory and methods to offer a better understanding of demographic fact in present as well as past populations (*Bernardi*, 2007). As a discipline, it started gradually from the last two decades of the twentieth century and is still under development. Both demography and anthropology deals with human populations as their


*Contributed by Dr. Maibam Samson Singh, Department of Anthropology, Sikkim University, Gangtok.

research object. Demography is mostly concerned with the dynamic forces which define population size, structure and their difference across time and space. Anthropology largely focuses on the dynamics of various population processes affecting different populations living under varied geographic and environmental conditions. So, in nutshell our focus would be on the ethnic groups and breeding isolates.

The other different branches of anthropology such as evolutionary anthropology, archaeology and paleodemography are characterized by the demographic methods to understand the bio-demographic structure of past or contemporary populations (*Bernardi*, 2007). Physical anthropologists on the other hand have their two most important demographic interests. The first interest explains the fundamental demographic factor of the species under conditions which are unaffected by modern life. Much of this work is paleodemographic depending on the evaluation of recovered skeletal materials. The second interest is to describe how 99 percent of human history spent in hunting and gathering has led by selection, to underlying physiology and psychology of human and indeed to the institutional structure and cultural components that are evident in demographic process today.

## 8.1 SCOPE

The scope of demography is broad from simple description of population changes over time and space to a complex growth and distribution of population with due attention to such determinants as migration, racial difference, psychology, social and economic class and geographical location. The necessity to study distribution, structure and changes in population had never so intensively felt as has been in the past few decades. It studies how small or large population are; how populations are composed as per age, sex, race, marital status, and other characteristics and how populations are distributed in physical space (*Bogue*, 1969). The variations in human population changes over time like variation in terms of size, composition and distribution. These changes are affected by several factors which include fertility, mortality and migration. Again, these factors are considered as the three basic demographic processes. If the population change in size, composition and distribution then these changes depend only on one or more of the three main demographic processes.

The population study deals with the population phenomenon which takes place and also changes in social, biological and economical settings. Population composition includes the measurable characters of population such as age, sex, marital status, educational level, religion, caste, race, etc. in a country during a particular period. The demographic studies try to discover the changes these characters influence on size and distribution of population and the variables responsible for the change. There are many factors affecting population distributions such as geographical location, social position and economy etc. It also studies by categorization of residence including both the rural and urban residence pattern, increasing urbanization, ratio of rural and urban population, locality etc. Fertility, mortality and migration are the primary aspect of demography. Demography studies the influence of biological limits, reproductive span, etc. in addition to the social, psychological and cultural factors which affect the fertility. The studies of mortality include age at death,

sex, cause of death, mortality trends and difference in mortality such as rural and urban. The study of migration involves the trends in migration movements, place of origin and destination, migration intervals, national and international migration.

## 8.2 RELATIONSHIP WITH OTHER BRANCHES OF SOCIAL SCIENCES

Demography studies several aspects of population which share close relationship with other disciplines. Some of the relationships are given below:

### 8.2.1 Demography and Anthropology

Both anthropology and demography share common research object i.e. human beings. Demography's main concern is with the dynamic forces defining population size and structure and their variation across time and space. Anthropological demography uses anthropological theory and methods to look into demographic phenomena. The main theoretical concept in anthropological demography includes culture, gender, institution, and political economy. Its empirical research approach includes both quantitative and qualitative methodology applied in case studies. For conducting research, ethnographic fieldwork and participant observation are considered main approach as it is the interpretative understanding of primary data and historical material. In addition, demography is also central to understanding human evolution and variation, because it's most important elements - fertility and mortality are fundamental aspects of evolution and variation.

Scholars in both anthropology and demography have occasionally come together as team in multidisciplinary research. Both the disciplines also created complex research models to construct on mutual strength and reduce disciplinary limitations thereby introducing the field of anthropological demography (*Majumdar*, 2010).

### 8.2.2 Demography and Sociology

Both the disciplines regard man and woman as social animals. Being a unit of society, human beings have to perform series of activities both as an individual and as well as partner of a larger group. Demography is used by sociologists both as a tool and a provider of social space for understanding social issues, social relations, social interactions, social reactions and the evolution and continuation of social processes. Demography is not just a study of population composition, sex ratio in population, prevailing or changing birth rates, death rates, migration rate or marriage rate. It is also important in the perspective of social, cultural and economic conditions of the human aggregate under scrutiny. Even studies about fertility, mortality and migration have a strong social base. The change in death rates, especially age, sex specific death rates and marriage rates are intimately related to social customs and cultural determinants. The measures suggest the practiced for controlling birth rate differ from one country to another which is primarily because of the social and cultural situation prevailing in those countries. A typical reciprocal relation appears to exist between social status on one side and fertility and mortality on other side. Class positions include superiority over others in explaining fertility, expectation of

life and some of the principal cause of mortality and morbidity in a population (*Majumdar*, 2010).

### 8.2.3 Demography and Economics

Economists provide major contribution to demography in both theory and application. For the graduate studies in economics, population studies are integral part of course. Even population size, its distribution and quality of skill are important factors in the total production and consumption process. Labour supply and labour productivity are reliant upon the size and skill composition of the population supply. Employment generation, resource management and distortion in income distribution are key issues that confront today's economists more than what they did hundred years back. There can be no uncertainty that raising the stage of living of people is closely related to the population growth. Investment priority, economic and development planning have frequently been derailed by the population explosion. Fertility, mortality, emigration and immigration, population density, urban-ward migration, etc. have direct or indirect effect by economic issues (*Majumdar*, 2010).

### 8.2.4 Demography and Human Ecology

Human ecology is mainly concerned with birth that gives the population base. Ecology as well concerned with environment and its association with every form of life on this earth. It views human population to an extent in which people share in exploiting and developing the same environmental resources. Human ecologists use demographic data as other disciplines do. According to Otis Duncan, human ecology gives a general perspective, concepts and specific hypothesis of the first rate significance to the demographers. Ecologists often use demographic variables as independent variables in many other causal models. For example, a small isolated population cannot have social organizations of the type of a large population is concentrated in a defined space (*Majumdar*, 2010).

### 8.2.5 Demography and Geography

Geography and demography are very close to each other due to their distributional perspectives. Population settlements appear to develop in places according to the climatic, temperature and rain fall experience of the place. Population growth and its dispersion have close association with geography. Birth, death and migration are broadly discussed in modern geography.

**Check Your Progress**

1) What do you understand by Demographic Anthropology?

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2) Explain in brief the relationship between demography and other disciplines.

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## 8.3 SOURCES OF DEMOGRAPHIC DATA

Demographers are more fortunate than others when it comes to data collection and develop their individual databases. Generally speaking, most of the data used have already been gathered for us, but not always. Indeed, some demographers do gather their own data, especially those who use anthropological perspectives and who are engaged in ethnographic research (*Greenhalgh*, 1994; *Riley*, 1998; *Riley* and *McCarthy*, 2003). However, most of us use data already collected and developed by other organizations. National censuses, registers, and surveys are the three basic sources of demographic data.

### 8.3.1 National Census

As per the United Nations (1958), a national census is the whole process of collecting, compiling, and publishing demographic, economic and social data pertaining at a particular time to everyone in a country or delimited territory. Everyone in a population and the entire demographic events that take place in the population are supposed to be registered in a national census. A census is like taking picture of a population once after every ten years. Its main objective is to find out data regarding the size, composition and distribution of the population. It also collects information regarding the size of the population and its social and geographic sub population, as well as data on their educational composition. Other typical census includes population data such as area of birth, citizenship, language, current migration experience, religion, and ethnic heritage, that refers to group distinction based on shared cultural origins (*Shryok et al.* 1976). Census has a very long history. The modern periodic census began halfway in the 18th century (Sweden, 1749, Norway and Denmark, 1769). Even though the first census was conduct in Virginia (USA) in 1624, the periodic census becomes an integral part of American Constitutions in 1787. In case of India, national census started in 1881. About 95 percent of the world's population have been counted in a national census conducted sometime during the decade of the 1990s (*Majumdar*, 2010).

There are two ways of counting people by following de jure method or by following de facto method (*Shryock*, 1964). In case of de jure method each person in a population is counted depending on their usual or normal place of residence in the country. In case of de facto method, each person in the population is counted according to his/her geographical location on the day of the census undertaking. De facto type is more common than the de jure method in more than 230 countries conducting national census (*Wilmoth*, 2004).

Census data are very important for the performance of government bodies in the present day context. It gives helpful and essential information of people to government officials in their country. Census statistics are utilized by the authorities in making public coverage on problems such as what number of kids the general public faculties want to serve and where to place brand new roads.

It also provides data on death rates, crime rates, per capita income figures, and other statistics for local and national governments administration. Even the

private business needed census data for their market analyses and advertising activities (*Anderson*, 2003). India uses census head count to determine the size of representatives both in parliament and assembly, all local bodies from a particular state as also to decide on the share of revenue and assistance from the central budget for different states and other purposes (*Majumdar*, 2010).

### 8.3.2 Registration System

Registration system is a continuous collection of major population events, often births, deaths, marriages, divorces and sometimes migrations. Registration data of demographic events such as birth or death which are registered with government are generally compiled and published annually or monthly. Although it applies mainly to births and deaths, many countries do maintain registrations of marriages, divorces, and abortions. A population register is a list of people that includes the name, date of birth, address, and a personal identification number. Some countries have maintained some kind of population register, and many of the other countries either have them in place or are planning to implement them. The United States does not maintain any type of national population register. The earliest example on record of a population register of families and associated household events was in China during the Han Dynasty (205 BC-AD 220). Irene Taeuber (1959) recorded that the demographic tradition of China and the East Asian region was a population registration. Its main function was only gathering of demographic events but also to control the population at the local level (*Bryan*, 2004).

In British occupied India, birth registration was started in the year 1670, death in 1720 and marriage much earlier in 1604. Since the promulgation of Birth and Death Registration Act, 1969, registration of birth and death has improved considerably (*Majumdar*, 2010). Generally, the Municipalities, Corporations and Panchayats or local bodies were given responsibility for maintaining registers for births and deaths. The hospitals, health centres, nursing homes, etc. send periodic reports of birth and death to their respective municipalities. When births and deaths occur outside institutional care, certificates from the doctors are submitted to municipality for registration in a given format. The registration offices issue certificate of registration. In 2001, approximately 55 percent of births and 45 percent of deaths were registered at a national level in India.

Today, population registrations are important as they hold information on birth and death records. Simon Szreter (2007) has written that the registration of one's birth and death are fundamental human rights. International Covenant on Civil and Political Rights (ICCPR) of the United Nations states that every child shall be registered immediately after birth and shall have a name (Szreter, 2007). A nation must have complete information regarding the patterns and trends of mortality so that appropriate action can be taken up to protect and improve the life expectancy of their populations. For inheritance of property or putting up claims for insurance and bank deposits, death certificate is made mandatory in India (*Majumdar*, 2010).

### 8.3.3 Surveys

The third source of demographic data is surveys. Demographers rely often on surveys because censuses and registration systems do not include the extensive

kind of information required to address some of the critical demographic questions. Demographers are better able to find out fundamental patterns of demographic behaviour by conducting surveys to carefully chosen random samples of the larger populations (*Poston* and *Bouvier*, 2010). They often collect data interest to demographers which are not included in censuses and registers. This is mainly true with respect to the study of fertility, while it also applies to mortality and migration.

For collection of demographic data, surveys are very important source second only to census. From user viewpoint, surveys are sometimes more significant and dependable than census. The survey data are much fine tuned since the data are collected under direct supervision of professional persons, specially trained field staff. In India, surveys such as National Sample Survey, Sample Registration Scheme etc. which are getting vital population data have gained momentum in the recent past for various reasons. It is used in addition to the current census on issues which cannot be covered through census. It also provides check on the exactness of the census count along with census. Survey under the aegis of Census Commissioner is conducted on more complex social and economic issues (*Majumdar*, 2010).

**Check Your Progress**

3) Define Census? Discuss the importance of population census.

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4) What is de jure and de facto method of population counting?

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## 8.4 DEMOGRAPHIC PROCESSES

Fertility, mortality and migration are three important demographic processes that determine the changes in population size, composition or distribution.

### 8.4.1 Fertility

Fertility refers to the actual production of children, which in the strictest sense is a biological process. It is different from fecundity. Fecundity refers to the reproductive capability of women during her whole reproductive period. Even though the production of child is a biological process, the different activities and events which lead to given birth are affected by the social, economic, cultural and psychological characteristics of the woman and the man, as well as by the environment in which they live.

There are two ways of studying fertility. Micro fertility analysis refers to the fertility of individual woman and man. Fertility of the person can be studied through: 1) examining the number of births a woman (or man) has produced by a

given point in time. 2) examining the number of births of woman (man) has had by the end of the child bearing years; and 3) focusing on the timing and spacing of birth at different stages of the life cycle (*Poston* and *Bouvier*, 2010). Macro fertility analysis determines the rate at which birth occurs in population or sub-population during a given period of time. Rather than studying the fertility of persons, macro fertility analysis studies the fertility of population (*Poston* and *Frisbie*, 2005). One reason demographer measure fertility at the macro level is to evaluate it with mortality, and to compute rates of reproductive change. They also compare the fertility levels of different types of sub-populations over time. There are several factors affecting fertility change which includes biological, physiological, socio-economic factors, lifestyles etc.

Demographers are paying attention in various social, economic, cultural and environmental factors that influence both the possibility of women having a baby and the number of babies she will have in her lifetime. Demographers have shown, for example, that the more years of education a woman has, the fewer will be her number of children. Women who attained higher education tend to marry later and also start a family later, compare to women who attended school for a shorter period of time. Usually, the higher a person's socio-economic status, the fewer children that person is likely to have. In industrialized societies, women employed in the labour force tend to have fewer children than women who are not so employed. Levels of child bearing also tend to be lower in urban than in rural areas. This is particularly true in more modernized countries, even though in the past three or four decades, the difference between rural and urban child bearing has diminished. As per National Family Health Survey (NFHS-4) of India, women in rural areas have higher fertility on average than women in urban areas. Women with no schooling have more children than women with 12 or more years of schooling. Women from low economic status have more children on overage than women from high economic status. The most important point to remember about fertility is that fertility rates are heavily conditioned by social, economic, psychological, cultural and environment factors (*Poston* and *Bouvier*, 2010). In the year 1956, two well known demographers, Kingsley Davis and Judith Blake, wrote an influential paper about the behavioural and biological variables that are intermediate and thus directly influence fertility. According to them, there are three variables such as intercourse, conception, and gestation which should be considered as intermediate to the various other social, economic, cultural and environment factors influencing fertility.

### 8.4.2 Mortality

Mortality refers to the relative frequency of deaths in a population. The two different concepts which were used by demographers when referring to mortality, namely, the life span, which is the numerical age limit of human life and life expectancy, which is the average expected number of years of life to be lived by a particular population at a given time (*Kintner*, 2004). Each and every one of us has been born and will die. Death will not take place at the same time for everyone. Some of us will die earlier than others. Whereas death is a certainty, the length of time we live depends on many factors; over some of them we have no control, but over other factors we have lot of control. The impact of mortality varies significantly according to social and demographic characteristics. People who belong to higher social classes live longer as compare

to those belong to lower social classes. Married people live longer than single, separated, or divorced people (*Poston* and *Bouvier*, 2010). Death is considered as complex behaviour. There are literally thousand different ways to die. Some cause of death occurs frequently than others. It can be due to famine, war and diseases such as influenza, pneumonia, smallpox, tuberculosis, HIV/AIDS, cancer, diabetes and other related diseases. Mortality is heavily influenced by a person behaviour and lifestyles choices. Deaths in this stage are caused due to social pathologies, like alcoholism, accidents, suicide and homicide, even some lifestyle factors, such as smoking and diet. There are also some environmental and socio-economic forces that influenced mortality. These forces include climate, weather, standard of living, housing condition, population density, industrial development, sanitation, medical facilities, occupation, the frequency of travel by air and other means of transport and the pursuit of hazardous sports such as motor racing, and political condition, especially war.

### 8.4.3 Migration

Migration is defined as the movement of people from one place to another within the country or outside. Persons may be added to a population by moving into it or subtracted by moving away from it. Unlike birth and death which occur to each of us once and only once, migration may occur on several occasions, or we may never experience migration. Demographers distinguish between movers and migrants. Any person who changes residence, whether the change involves moving across the street is a mover. A migrant is a person whose residential move involves the crossing of political boundary. Movement usually involves changes in one's school, job, church, doctor, library, pub, shopping centre, automobile mechanic, and other institutional aspects of daily life. In contrast, with local movement, a permanent change in residence does not involve change in the main institutions in the mover's daily life (*Poston* and *Bouvier*, 2010).

Internal migration and international migration are the two main types of migration. The dynamics of the two kinds of migration differ significantly. The change of permanent residence within a country, involving a geographical move which crosses a political boundary is the internal migration. It can be in-migration, which refers to the residential migration of persons to an area of destination, and out migration, which refers to the migration of persons from an area of origin. However, International migration is the migration that occurs between countries. It could be immigration and emigration. Immigration is defined as the migration of people into a new country for the idea of establishing a permanent residence. This concept is analogous in the study of internal migration to in-migration. On the other hand, emigration denotes the permanent departure of people from a country and this concept is analogous to out migration in the study of internal migration.

Migration is a significant event not only for individuals but also for communities as well. Migration from one area to another has the effect of decreasing the size of the population in the area of origin and increasing in the area of destination. Considering the dynamics of the population growth for communities, migration is the single most important of the three demographic processes. Differences in birth rates and death rates between communities of the same country are generally small compare to the differences between the communities in

migration. Migration is the major method for re-distributing the population within the country (*Bogue*, 1969; *Poston* and *Frisbie*, 2005; *Poston et al.* 2006).

**Check Your Progress**

5) What are the two ways of studying fertility?

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6) Write down the difference between internal and international migration.

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## 8.5 SUMMARY

Anthropological demography is a specialized field of anthropology that offers a better understanding of demography using theories and methods of anthropological discipline. It has both the aspects of anthropology and demography wherein demography is specifically concerned with the dynamic forces which define population size, structure and their difference across time and space. Anthropology largely focuses on the dynamics of various population processes affecting different populations living under varied geographic and environmental conditions. The present unit studies several aspects of demography and discusses its close relationship with other disciplines of social sciences like Sociology, Economics, Human Ecology and Geography. National censuses, registration systems and surveys are the three basic sources of demographic data. Each one is an important source of data for demographic study. Demographic analysis requires data from all three sources. Lastly, three basic processes, fertility, mortality and migration that determine the changes in population size, composition or distribution have been discussed.

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## 8.7 ANSWERS TO CHECK YOUR PROGRESS

1) Anthropological demography is a specialty within demography which uses anthropological theory and methods to provide a better understanding of demographic phenomenon in current and past populations. For further details refer section 8.0

2) Demography studies different aspects of populations and shares close relationship with other branches of social sciences, i.e. Sociology, Economics, Human Ecology and Geography etc. For further details refer section 8.2.

3) According to United Nations (1958), a Nation Census is the total process of collecting, compiling, and publishing demographic, economic, and social pertaining at a specified time to all persons in a country or delimited territory. For further details refer section 8.3.1.

4) In De jure method, the census covers the entire territory of the country and counts persons according to their usual or normal place of residence in the country. De facto method also covers the entire territory of the country but

counts each person in the population according to his/her geographical location on the day of the census undertaking. For further details refer section 8.3.1.

5) There are two ways of studying fertility. Micro fertility analysis refers to the fertility of individual women (and man). Rather than studying the fertility of persons, macro fertility analysis studies the fertility of population. For further details refer section 8.4.1.

6) Internal migration is the change of permanent residence within a country, involving a geographical move that crosses a political boundary. International migration is migration that occurs between countries. For further details refer section 8.4.3.

# UNIT 9 INDIAN DEMOGRAPHY*

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**Learning Objectives**

After reading this Unit, you will be able to:

- Understand the concept and elements of demography;
- List factors affecting population dynamics;
- Define and calculate Fertility and Mortality Rates; and
- Explain and state types of migration.

## 9.0 INTRODUCTION

Demography is the systematic and scientific study of human populations. The term "Demography" has a Greek origin and is composed of two words, demos (people) and graphy (describe) which means "the description of people". Being

*Contributed by Dr. Ratika Samtani, Amity Institute of Anthropology, Noida, U.P.

a scientific study of human population, it broadly includes study of changes in population size, composition and its distribution. In other words, demography studies the structure and composition of the population, various trends and processes associated with population including – changes in population size; patterns of birth, death and migration across varying age groups. Demographic studies also focus on the process of counting or enumeration; which includes census or survey and the systematic collection of data on the people residing within a specified region.

Importance of Demographic data: Demographic data is any data that provides an understanding of population size, distribution, and composition (*Murdock* and *Ellis*, 1991). Moreover, it is vital for planning and implementation of policies, for better economic development and general public welfare. In addition, health status of a community also depends on the dynamic relationship between number of people, their composition and distribution. Demographic variables can assist in the planning of health related services and can deliver a basis for predicting future developments and making informed decisions for the formulation, implementation, and evaluation of plans, policies and programs for education, housing, health, employment and other forms of social services.

According to Bloom, the world experienced a dramatic population growth during the twentieth century, with the number of populations doubling from 3 to 6 billion between 1960 and 2000 (*Bloom*, 2011). India witnessed rapid population growth during this period from 448 million to 1.04 billion and to 1.21 billion in 2010 (*Bloom*, 2011). Global population grew at roughly 2% per annum from 1960-2000, a level that is unsustainable in the long term, as it translates into population doubling every 35 years. According to the latest statistics, India's population is currently growing at a rate of 1.4% per year, far surpassing China's rate of 0.7%. This may result in India surpassing China with respect to population size in less than 20 years (*Bloom*, 2011).

## 9.1 DEMOGRAPHY: DEFINITIONS AND CONCEPTS

Demography and Population studies: The study of human population is mainly known as Demography and Population studies. In many instances, these two terms are used interchangeably, but some scholars also try to distinguish between the two. Broadly speaking, Population studies are concerned with understanding what are the kinds of changes taking place in the size and nature of human populations. Demography refers to the hard core analysis of numbers while population studies look at the behavioral aspects affecting the reproductive behavior of people. Demographic determinants such as fertility, mortality and migration are the three basic aspects which influence the population of a particular place.

Most demographic concepts are expressed as rates or ratios and they involve two numbers.

### 9.1.1 Mortality Measures

Information about mortality or how deaths take place within a community is very important from the point of view of estimating the health of a community

and understanding how it will grow. If the death rate is more than the birth rate, the number of people (population) will decrease and the reverse trend shall be observed if the death rate is lower than the birth rate. Following is the list of measures commonly used for measuring mortality.

### 9.1.1.1 Crude Death Rate (CDR)

Crude death rate is the simplest and the most commonly used measure of mortality. It is defined as the ratio of the total deaths of a specified year to the total mid-year population, multiplied by 1000. It can be calculated as follows:

$$\text{Crude Death Rate} = \frac{\text{No. of death during the year in a given Geographic area}}{\text{Mid-Year population in the same year and same area}} \times 1000$$

**(Source: MOSPI, 2015)**

### 9.1.1.2 Infant Mortality Rate (IMR)

The deaths under one year of age are called infant deaths. The infant mortality rate is defined as the number of infant deaths occurring in a community within a specified calendar year per 1000 live births in the same community during the same calendar year (MOSPI, 2015).

$$\text{Infant Mortality Rate (IMR)} = \frac{\text{No. of deaths in age group 0-1 year after birth in a year}}{\text{Total number of live births in that year}} \times 1000$$

**Check Your Progress**

1) What does Infant Mortality mean?

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### 9.1.1.3 Maternal Mortality Rate (MMR)

The maternal mortality ratio is the number of women who die as a result of complications from pregnancy or childbearing in a given year per 100,000 live births in that year. This represents special case of sex-related mortality. It represents death cases of women who die during pregnancy and childbirth inclusive the first 42 days after the delivery (WHO, 1994).

In other words, the maternal mortality rate is defined as the number of female deaths due to puerperal causes among the residents of a community during a specified year per 100,000 live births.

$$\text{Maternal Mortality Rate (MMR)} = \frac{\text{Number of female deaths due to puerperal causes}}{\text{No. of Live births during same year}} \times 1000$$

**Check Your Progress**

2) What is the Maternal Mortality Rate?

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## 9.1.2 Fertility Measures

Fertility refers to the ability of females to produce healthy offspring. The term fertility denotes the ability to reproduce by natural means. In demographic terms, fertility refers to the actual production of offspring. There are various important social, biological and economic factors that determine fertility such as age at marriage, duration of marriage, child survival, spacing of children, economic stability, educational status, cultural beliefs and practices.

The physical capacity of bearing a child is termed "Fecundity". Fecundity is the potential reproductive capacity of a female.

Some of the more common demographic measures used in relation to fertility and/ or fecundity are given below.

### 9.1.2.1 Crude Birth Rate (CBR)

It is defined as the number of live births that occur in a community per 1000 mid-year population of that community in a year (*Bhende & Kanitkar*, 2011). In other words, crude birth rate is the ratio between the specified number of people in a population over a given period of time and the number of live births that occur in a population over the same period of time (*Bhende & Kanitkar*, 2011). Most annual rates, such as the birth rate, relate demographic events to the population at midyear (July 1), which is considered to be the average population at risk of the event occurring during the year (NIHFW, 2014). The crude birth rate varies with social, economic, political, cultural, geographical and biological factors at a particular time in a country.

$$\text{Crude Birth Rate} = \frac{\text{Total No. of live births in a year}}{\text{Mid-Year Population}} \times 1000$$

### 9.1.2.2 General Fertility Rate (GFR)

It is the number of live births that occur in a country, in a giver year, per 1000 mid-year population of women in the childbearing age group of that country in that respective year (*Bhende & Kanitkar*, 2011). In other words, general fertility rate refers to the number of births per 1000 women (ages 15-49) in a given year. GFR includes all women of childbearing age, both married and unmarried.

### 9.1.2.3 Age-specific Fertility Rate

The Age specific fertility rate is defined as the number of births per year 1000 women of a specified age. Age specific fertility rates may be computed either for single years of age or for age intervals (MOSPI, 2015).

In other words, Age-specific fertility Rate refers to the number of live births that occur in a country to women in a particular age (a year or age group) per mid-year population of women of that age in that country in that particular year. e.g. females in the age group 20-24 years.

$$\text{General Fertility Rate (GFR)} = \frac{\text{No. of live births per year}}{\text{Mid-Year female population (ages 15-49)}} \times 1000$$

### 9.1.2.4 Total Fertility Rate (TFR)

The Total fertility rate estimates the average number of live births that a woman will have during her total reproductive span (*Bhende & Kanitkar*, 2011). In other words, the total number of children the average women in a population is likely to have based on current birth rates throughout her life defines the total fertility rate. The total fertility rate is the sum of age-specific fertility rates of a woman of a country per 1000 mid-year population of women in the reproductive age group of that country in that particular year. This is the best single measure to compare fertility across populations in a country.

$$\text{Age-specific Fertility Rate} = \frac{\text{No. of live births (Age-group)}}{\text{Mid-Year total female population in each age group}} \times 1000$$

### 9.1.2.5 Net Reproductive Rate (NRR)

The average number of daughters that would be born to a woman (or a group of women) during her lifetime if she passed through all her childbearing years conforming to the age-specific fertility rates and age-specific mortality rates of a given year. This is similar to the GRR except that it includes the effect of mortality that would cause some women to die before completing their childbearing years (NIHFW, 2014).

### 9.1.2.6 Gross Reproduction Rate (GRR)

The GRR is the average number of daughters that would be born to a woman (or group of women) during her lifetime if she passed through her childbearing years conforming to the age-specific fertility rates of a given year. The gross reproduction rate reflects the potential of women in a country to produce their own kinds, which is female giving birth to female (*Bhende & Kanitkar*, 2011). This rate is like the TFR except that it counts only daughters and literally measures "reproduction"— a woman reproducing herself by having a daughter (NIHFW, 2014). The gross reproduction rate highlights the importance of female in the fertility of a country and shows that the fertility process can be handed over from one cohort of female population to another. In order to obtain gross reproduction rate (GPR), first add the single year age-specific fertility rates (ASFR) on woman of a country that covers the entire 30 years' reproductive age span and then multiply the product by the new born sex ratio of the country. It can also be calculated by simply multiplying the total fertility rate (TFR) of the country by the new born sex ratio of the country (*Bhende & Kanitkar*, 2011).

### 9.1.3 Migration

This is the third important determinant of the total population of the place after births and deaths and so demographic study is also concerned with how and why people move from one place to another. Migration is either internal or international. The internal migrant is referred to as an in-migrant or an out-migrant and the person who crosses international borders an immigrant or emigrant depending on whether s/he is coming in or going out.

### 9.1.4 Sex Ratio

Sex ratio is the demographic term that is used to define the proportion of males to females in a given population. It is measured as the number of females per 1000 males in one calendar year. As per 2011 census, total Female Sex Ratio in India is 940 females per 1000 males (Census, 2011, Govt. of India).

**Check Your Progress**

3) What do you understand by sex ratio?

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### 9.1.5 Population Pyramid (Age-Sex Structure)

Demographers typically use population pyramids to depict the age and sex structure of a population (*Wolf et al*, 2011). When the population of a particular region is arranged graphically according to age-groups and sex, we get a graph which resembles a pyramid. This population pyramid provides information about the composition of a particular society and its situation. Historically for most nations, particularly in those with persistently high fertility rates, they resemble a pyramid, with a wide base representing large numbers of younger age groups and more narrow bands near the top representing smaller numbers of older people near the end of their natural life span (*Wolf et al*, 2011). In a typical developed nation, where the birth rates have declined considerably long time ago and the life expectancy of the population is quite high, the population pyramid is in the shape of a column.

### 9.1.6 Life Expectancy

This is a measure of how many years a person is expected to survive in the prevalent situation. This measure can be calculated at any particular age, though the common practice is to refer to life expectancy at birth. In India this was not the case till very recently because despite staying at home women had to face much higher risks primarily related to maternal mortality.

### 9.1.7 Growth Rate

Crude death rate is subtracted from crude birth rate, the net residual is the current annual growth rate, exclusive of migration. Growth rate refers to the overall growth of the population and can be represented either annually or over a period of ten years. Population growth in India has been slowing in

recent decades from an annual growth rate of 2.5 per cent during 1971-81 to an estimated 1.3 per cent as of 2011-16 (Economic Survey, 2018-2019). All major states have witnessed a marked deceleration in population growth during this period. A key driver of this trend has been the steady decline in India's total fertility rate (TFR) since the mid-1980s (Economic Survey, 2018-2019). These developments suggest that India has entered the next stage of demographic transition with population growth set to slow markedly in the next two decades along with a significant increase in the share of working-age population (the so-called "demographic dividend" phase).

### 9.1.8 Population Projection

This is an estimation or forecasting of the population of a particular region at some point in the future which is crucial for planning and policy formulation. It involves computations depicting the future course of a population's size, its structure, and its interaction with dynamics such as fertility, mortality, and migration. The projection is constructed based on assumptions about the future course of those population dynamics (NIHFW, 2014). According to Economic Survey 2018-2019, India is set to witness a sharp slowdown in population growth in the next two decades. Although the country as a whole will enjoy the "demographic dividend" phase, some states will start transitioning to an ageing society by the 2030s (Economic Survey, 2018-2019).

## 9.2 INTRODUCTION TO DEMOGRAPHIC PROFILE OF INDIAN POPULATIONS–AN OVERVIEW

Considering the demographic profile of Indian population, the country has observed a drop in its population growth rate in the last four decades (1971-2011). Fertility rates have fallen by 2.7 per cent per annum (2.8 to 2.5) over the 2006-10 period— a faster decline than the decline of 1.6 per cent per annum (3.1 to 2.9) in the preceding five years (National Institute for Heath and Family Welfare. 2014). According to the Sample Registration System (SRS), 2012, it estimates that twenty one states and union territories (UTs) have achieved the replacement level of fertility, though fertility remains high in several states, highlighting different stages of demographic transition among the states, leading to difference in their timelines to achieve population stabilization (NIHFW, 2014). Seven states that have witnessed a high fertility rates are Bihar (3.6), Uttar Pradesh (UP) (3.4), Madhya Pradesh (MP) (3.1), Rajasthan (3.0), Jharkhand (2.9), Chhattisgarh (2.7), and Assam (2.4), of which six belong to the empowered action group (EAG1) states. All of the EAG states and Assam also collectively account for the highest number of births, as well as infant, under-five, and maternal deaths in the country, bringing a focus on poor maternal and child health (MCH) indicators and their correlations with high fertility rates. The main aim of the National Rural Health Mission (NRHM) is to reduce maternal and child mortality rate in the country, and the government is making strategic investments to improve the MCH indicators in the country having a specific focus on high-fertility states (NIHFW, 2014).

Outputs of Population Projections and Expected Levels of Achievement (ELAs): (From National Institute for Heath and Family Welfare, 2014).

## Population trends

- India's population is likely to reach 1.381 billion in 2022. The country is likely to add 170 million persons during the next decade, which is about 10 million fewer people added compared to the last decadal increase (NIHFW, 2014).
- A rising trend in the contribution of EAG states' populations to the total population of the country (43.4% in 1991, 44.6% in 2001, and 46% in 2011) has been observed. The population share of eight EAG states and Assam is likely to increase from 46.05 per cent in 1991 to 49.70 per cent in 2022, and the population of the EAG states is likely to cross the combined population of all 26 non-EAG states/UTs between 2020 and 2022 (NIHFW, 2014).
- The projected per cent population in the 0–14 year age group shows a continuous decline over a period of time across all the states and India. The north Indian states have a window of opportunity to utilise the demographic dividend, as a large number of working people will enter into the job market. This group of people will also require access to Family Planning services and products in order address the unmet need for family planning (NIHFW, 2014).
- The slowest decline in Parity Progression Ratio (PPR) has been experienced in the states of Bihar and UP. The analysis emphasizes the significant impact of child mortality among women in all parity categories.
- More educated women tend to have a lower number of children ever born compared to less educated or uneducated women.
- Women, who experience physical violence, characterizing lower status in the house, depict higher fertility or children ever born.
- Increased use of contraception (51%) has been the major cause for fertility decline in India, followed by a pattern of delayed marriage (45%). As per the analysis, abortions show no impact, and a very low decline (3%) has been caused by postpartum infecund ability (NIHFW Report, 2014).
- Among the EAG states, delayed marriage has contributed to fertility decline the most in UP (42%) and the least in Rajasthan (23%).
- According to the NIHFW report, 2014; Variations in two major factors—marriage and contraception— are the primary proximate causes of fertility differences among EAG states. The analysis conducted to assess the magnitude of change caused due to the proximate determinants shows the use of contraception and delay in age at marriage as major contributing factors in fertility decline.
- Among the EAG states, the use of contraception has led to the decline in fertility levels mostly in the states of MP and Uttarakhand, while Bihar and UP have shown the lowest effect of contraception in explaining fertility decline.
- As per data from NFHS-2, abortion has not impacted fertility control, though there has been evidence that fertility in TN has been impacted by abortion.

- Among the EAG states, Postpartum insusceptibility ranged between 11 months in Rajasthan to about 14 months in Bihar and Jharkhand. The mean duration of breast feeding ranges from 7.4 months in TN and 13.3 months in Bihar and Jharkhand.
- Mean length of "sexual abstinence" is estimated at 5 months. AP, TN, and Odisha show the maximum impact of "postpartum insusceptibility" in comparison to the other states.

## 9.3 THEORIES ON DEMOGRAPHY

**Malthusian Theory of Population Growth:** The Malthusian theory of population growth is one of the most famous theories of demography and the Malthus's theory of population growth is outlined in his Essay on Population (1798). It was given by Thomas Robert Malthus who was an English cleric and scholar. According to Malthus, food increases in a slow arithmetical ratio, while man grows in geometrical ratio. In other words, while population tends to grow in geometric progression (i.e., like 2, 4, 8, 16, 32 etc.), the agricultural production can only grow in arithmetic progression (i.e., like 2, 3, 4, 5 etc.). Since population growth may invariably exceed growth in production of subsistence, unless prevented by powerful and obvious checks. Malthus alleged that famines and diseases kept a check to population growth which were inevitable as they were nature's way of dealing with the disparity between food supply and increasing population.

**Demographic Transition Theory:** It is a model that describes population change over time. It is based on an interpretation begun in 1929 by the American Demographer Warren Thompson, of the observed changes, or transitions, in birth and death rates in industrialized societies over the past two hundred years or so. It explains how the population of a particular region changes over a period of time with advances in the economic and social conditions. According to this theory, early agricultural life was categorized by high rates of birth and death with no consequent increase in the population. This was followed by the early growing phase, where due to advances in the field of health services and economic situation the death rates declined fast but the birth rates were still high. In the third phase which can be termed the late expanding phase- the birth rates declined. In the fourth or low stationary phase, birth rates and death rates are again equal to each other but both the figures are very low. In the fifth and final phase, the birth rates reduce even further while death rates have reached their lowest possible level and are more than the birth rate. Here the overall population starts declining.

## 9.4 SOURCES OF DEMOGRAPHIC DATA

In India, main sources of demographic data are:

- Population Census
- Civil Registration System
- Sample Registration System
- National Sample Survey

- Health Surveys, such as National Family Health Surveys (NFHS), District level Household Surveys (DLHS).

The Population Census, Civil Registration System and the Sample Registration System are organized and conducted by the office of the Registrar General, India; whereas the National Sample Surveys are being launched by the National Sample Survey Organization (NSSO). The National Family Health Survey and the district level health Survey are being conducted under the aegis of Ministry of Health & Family Welfare for evaluation of reproductive and child health programmes.

**Population Census:** The enumeration of the entire population of a country or a region at a particular time is known as a census. Usually census is conducted at definite intervals which in India occurs after every ten years. Information on every individual is separately recorded, and every effort is made to cover the entire territory. Census is the primary source of population data at the national or at the state level; the data which is thereby required for various administrative, planning and research purposes. The Registrar General is mainly responsible for census, registration of birth and deaths, and for conducting other relevant surveys. The census is conducted in accordance with the Census Act of India (1948).

**Civil Registration System:** Civil Registration System (CRS) in India is the unified process of continuous, permanent and compulsory recording of the vital events (births, deaths, still births) and characteristics thereof. The Registration of Births and Deaths Act, 1969 provides for the compulsory registration of births and deaths. For the country, the requirement of an effective Civil Registration System is a must as it has important administrative and statistical uses. The data generated through a complete and up-to-date CRS is essential for socio-economic planning and to evaluate the effectiveness of various social sector programmes. The data also serves as the corner stone of public health system by providing various vital statistics like Sex Ratio, Infant Mortality Rate, Still Birth Rate. Statistics derived henceforth help in targeted policy formation. (Presentation by Anil Sant, Joint Secretary and Addl. Registrar General, Office of the Registrar General, India available at https://getinthepicture.org/)

**Sample Registration System (SRS):** The SRS is a demographic survey for providing reliable annual estimates of infant mortality rate, birth rate, death rate and other fertility and mortality indicators at the national and sub-national levels. Initiated on a pilot basis by the Registrar General of India in a few states in 1964-65, it became fully operational during 1969-70. The field investigation consists of continuous enumeration of births and deaths in selected sample units by resident part-time enumerators, generally Anganwadi workers and teachers; and an independent retrospective survey every six months by SRS supervisors.

**National Sample Survey:** The National Sample Survey (NSS) which came into existence in the year 1950, is a multi-subject integrated continuing sample survey programme launched for collection of data on the various aspects of the national economy required by different agencies of the Government, both Central and States (NSSO, 2001). The wide variety of subjects brought under the coverage of surveys conducted so far by the NSS can broadly be classified

under four categories: (1) Household surveys on socio-economic subjects, (2) Surveys on land holding, livestock and agriculture, (3) Establishment surveys, and enterprise surveys (4) Village surveys (NSSO, 2001).

Under the first category come the surveys on population, birth, death, migration, fertility, family planning, morbidity, disability, employment & unemployment, agriculture and rural labor, household consumer expenditure, debt, and investment, savings, construction, capital formation, housing condition and utilization of public services in health, education etc. Under the second are covered the surveys on land holding, land utilization, livestock number, product and livestock enterprises. Surveys on medium and small industrial establishments and own-account enterprises not covered by the Annual Survey of Industries (ASI), surveys on other non-agricultural enterprises in the unorganized sector and collection of rural retail prices from markets and shops in rural areas belong to the third category. Finally, the collection from sample villages of various types of information on the availability of infrastructure facility in Indian villages constitute the fourth (NSSO, 2001).

**Health Surveys:** The first National Family Health Survey (NFHS) was conducted in 1992-93. The primary objective of the survey was to provide data on fertility, mortality, morbidity, nuptiality, family size preferences, knowledge and practice of family planning, the potential demand for family planning services, the level of unwanted fertility, utilization of antenatal care services, breastfeeding/and food supplementation practices, child nutrition and health immunization and infant and child mortality. Ministry of Health and Family Welfare, Govt. of India, had selected the International Institute for Population Sciences, Mumbai, as the nodal agency for the conduct of surveys. The survey covers a number of questions pertaining to topics such as reproductive health, women's autonomy, domestic violence, women's nutrition, anemia and salt iodization, Obesity among men and women, knowledge, attitude and behavior with regard to HIV/AIDS and its prevalence, questions on several emerging issues such as perinatal mortality, involvement of men in maternal health care, adolescent reproductive health, sexual behavior, family education etc.

## 9.5 NATIONAL POPULATION POLICY OF INDIA

The overriding objective of economic and social development is to improve the quality of lives that people lead, to enhance their well-being, and to provide them with opportunities and choices to become productive assets in a society.

The National Population Policy, 2000 (NPP 2000) affirms the commitment of government towards voluntary and informed choice and consent of citizens while availing of reproductive health care services, and continuation of the target free approach in administering family planning services. The NPP 2000 provides a policy framework for advancing goals and prioritizing strategies during the next decade, to meet the reproductive and child health needs of the people of India, and to achieve net replacement levels (TFR) by 2010. It is based upon the need to simultaneously address issues of child survival, maternal health, and contraception, while increasing outreach and coverage of a comprehensive package of reproductive and child health services by government, industry and the voluntary non-government sector, working in partnership.

The objective of the NPP 2000 is to address the unmet needs for contraception, health care infrastructure, and health personnel, and to provide integrated service delivery for basic reproductive and child health care. The long-term objective is to achieve a stable population by 2045, at a level consistent with the requirements of sustainable economic growth, social development, and environmental protection.

## 9.6 SUMMARY

Demography is the systematic, scientific and methodical study of human populations. Because demography is interested in changes in human populations, demographers focus on specific indicators of change. Two of the most important indicators are birth and death rates, which are also referred to as fertility and mortality. Additionally, demographers are interested in migration trends or the movement of people from one location to another. While India's population growth has slowed remarkably over the last few years, it's still growing faster than China and is expected to surpass China in population by 2028. Population growth in India has been slowing in recent decades from an annual growth rate of 2.5 per cent during 1971-81 to an estimated 1.3 per cent as of 2011-16 (Economic Survey, 2018-2019). India has also entered the next stage of demographic transition with population growth set to slow markedly in the next two decades along with a significant increase in the share of working-age population (the so-called "demographic dividend" phase).

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## 9.8 ANSWERS TO CHECK YOUR PROGRESS

1) The number of deaths per 1000 live births of children under 1 year of age in one calendar year.

2) The Maternal Mortality Rate (MMR) is the annual number of female deaths per 100,000 live births from any cause related to or aggravated by pregnancy or it management (excluding accidental or incidental causes). For its calculation, the number of deaths due to infant birth is divided by the total number of infant births.

3) Number of females per 1000 males in one calendar year.

# UNIT 10 INBREEDING AND CONSANGUINITY*

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**Learning Objectives**

After reading this Unit, you will be able to:

- Understand consanguineous marriages and inbreeding;
- Describe the degree of biological relationship;
- Elucidate the biological consequences of inbreeding; and
- Identify the prevalence of inbreeding in Indian population.

## 10.0 INTRODUCTION

In demographic studies, mating has a significant role in shaping the genetic structure of a population. Marriage in the Indian context shows a considerable variation among the different ethnic groups. Marriage between closely related individuals 'consanguineous marriage' is one of the common types of marriages practiced in India since ancient times. Here, closely related individuals mean sharing of common ancestors. India has a diverse culture; such type of marriage is observed very frequent in some communities, whereas it is considered taboo in some other communities. The consanguineous marriage is deeply rooted in the beliefs and socio-cultural norms of the society.

There are different forms of consanguineous marriages which are classified based on the magnitude of relationships. For example, a marriage between father and daughter, mother and son, brother and sister are considered highly



*Contributed by Dr. Huidrom Suraj Singh, Department of Anthropology, Manipur University, Imphal.

consanguineous and incestuous marriage as it took place within the direct descendants. Moreover, there are other types of consanguineous marriages such as first-cousins marriage, second cousin marriage and uncle-niece marriage practiced in human societies. Among the different types of consanguineous marriage, cousin marriage is the most common type found with appreciable frequencies in India.

The term inbreeding is defined as the mating of individuals who have one or more biological ancestors in common. It means mating between genetically related individuals. The progeny of consanguineous parents is, by definition 'inbreed.' Inbreeding is the outcome of Consanguineous marriages. The term consanguineous is more qualitative and often used in anthropology and social sciences in terms of describing marriage patterns. It describes the relationship of individuals through marriages. However, it is also used in studying human population genetics for its significant contribution in shaping the genetic structure of a population. On the other hand, inbreeding is more quantitative and often use in clinical genetics, describing the degree of biological relationship and consanguinity between the parents and their offspring. Inbreeding is departures from random mating and genetic consequences of consanguineous marriages.

**Marriage**

George Peter Murdock (1949) defined marriage is a universal institution that involves residential co-habitation, economic co-operation, and the formation of the nuclear family. It is a union between a man and a woman such that the children born to the woman are recognised as legitimate offspring of both partners (Notes and Queries on Anthropology 1951: 111)

Consanguinity increases the degree of inbreeding. In other words, inbreeding is considered to be the genetic consequence of consanguineous marriage. It has shown adverse outcomes on reproductive history, morbidity, and mortality in infancy. Moreover, it also has shown significant impacts on physical and mental disadvantages among the childhood and adulthood periods.

In the present unit, we shall try to understand the basic concept of consanguinity and inbreeding. We shall also discuss the biological consequences of inbreeding and prevalence of inbreeding in different Indian populations.

## 10.1 CONSANGUINITY

### 10.1.1 Definition of Consanguineous Marriages

The term consanguineous is originated from the Latin word 'consanguineous' meaning 'of the same blood'. It is defined as the biological relationship of individuals characterized by the sharing of common ancestors. Therefore, we can say that two individuals are consanguineous if they have at least one common ancestor. In simple words, consanguineous marriage is those marriages that take place between closely related individuals. We are all human beings to some extent, consanguineous as we are descended from a common ancestor. The consanguineous marriage is practiced in different societies at different degrees. The custom of consanguineous marriages in India could be traced back to several centuries (*Rao et al.*, 1975). In some societies, consanguineous

marriages have been encouraged, for example, in Egyptians and Incas favoured unions of brothers and sisters of the reigning dynasty to maintain 'royal blood' in the family. In India, consanguineous marriages are practiced by different communities. However, reasons for practicing such marriages are varied from one community to the other. It is generally associated with the strengthening of family ties and socio-economic purposes. Moreover, it is also practiced to maintain the purity of blood in the royal family members.

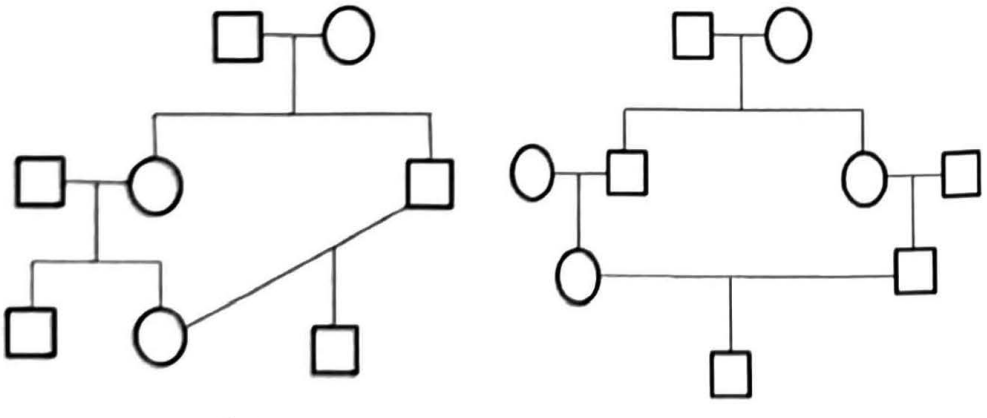
### 10.1.2 Types of Consanguineous Marriages

Consanguineous marriages are of different types, which can be categorised based on biological relationships. Such relationships can be expressed in terms of degrees. Marriage between an individual with parents (mother or father) or with full sibs (brother or sister) is called first-degree relationship. Such type of biological relationship such as father with daughter, mother with son, and sister with brother is generally considered as incest taboo by most of the societies.

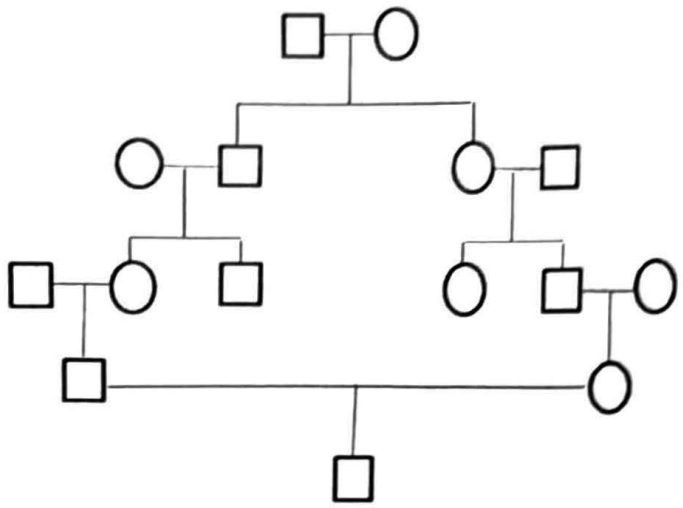
**Incest Taboo**

The term "incest taboo" is derived from a combination of two words 'incest' meaning the sexual relationship between biologically close relations (parents and children or between siblings) and 'taboo' meaning prohibition. In anthropology, taboo implies the avoidance of a specific behaviour or social action for fear or beliefs of harm by supernatural power. Hence, according to the anthropological point of view, the term 'incest taboo' refers to a cultural prohibition of sexual relations. Such sexual relationships between close blood relations are universal of cultural taboo. Claude Levi Strauss, one of the great French anthropologists, argued that incest taboo in human societies should be prohibited.

The biological relationship between an individual and his or her sib's offspring is called second-degree relationship. It is represented by uncle-niece marriage (Figure 10.1 a). Such a relationship could be in between brother with brother's daughter, brother with sister's daughter, sister with sister's son, and sister with brother's son. The other form of consanguineous marriage is between the first cousins, and it forms the third degree of biological relationship (Figure10.1b). It is followed by different levels of relationships such as fourth degree (second cousin, Figure10.1c), fifth-degree, and so on.



(a) (b)



(c)

**Fig. 10.1: Different forms of consanguineous marriage (a) Uncle-niece marriage; (b) First cousin marriage; (c) Second cousin marriage**

In case of third-degree relationship i.e. first-cousin marriage, there are four possible types of marriages of a person such as to father's brother's daughter (FBD), to father's sister's daughter (FSD), to mother's brother's daughter (MBD) and to mother's sister daughter (MSD). The FSD and MBD are called cross-cousin marriages whereas the FBD and MSD are known as parallel cousin marriages (Bittles, 2002).

**Check Your Progress**

1) What do you mean by consanguineous marriage? Discuss its effects on the genetic structure of a population.

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.....

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2) How degrees of biological relationships are measured?

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.....

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## 10.2 INBREEDING

### 10.2.1 Definition

The term inbreeding is defined as the production of offspring as a result of a mating between closely related individuals. Closely related individuals are those individuals who are having common biological ancestors. Therefore, the progeny of consanguineous parents is, by definition, inbred. Inbreeding is the genetical outcome of consanguineous marriage. In most societies, marriage regulates mating pattern, and consanguineous marriage leads to inbreeding. Inbreeding increases the degree of homozygosity to the offspring and also the expression of recessive traits.

## 10.2.2 Inbreeding Coefficient

The genetic relationship of individuals can be measured or quantified by using standardized mathematical formulae. In general, the genetic relationships can be measured by two basic measures, such as the coefficient of relationship (r) and coefficient of inbreeding (F). The term 'coefficient of relationship' was introduced by Sewall Wright in 1922. It measures the degree of consanguinity between two individuals. In other words, it is the proportion of genes identical by descent, which is shared by two individuals. It is calculated by using the following formula:

$$r = \{(1/2)^n\}$$

Where n is the number of steps apart between two individuals through their common ancestor. For example, the coefficient of relationship (r) of two individuals (A and B) who are related as first cousins can be calculated as follows:

$$r = \{(1/2)^4 + (1/2)^4\}$$

$$= 1/8$$

Since the total number of steps (n) from A to the other person B through their common ancestors is 4 as both A and B share two common grandparents.

Example of Finding the number of Steps 'n'

**Path I** = A ------- Father ------ Grandfather ------ Aunt (Fathers' sister) ------ B

(through grandfather) Step 1 Step 2 Step 3 Step 4

**Path II** = A ------- Father ------ Grandmother ----- Aunt (Fathers' sister) ------ B

(through grandmother) Step 1 Step 2 Step 3 Step 4

The coefficient of inbreeding (F) is defined as the proportion of gene at which an individual of consanguineous mating is homozygous by descent. Generally, it is calculated by using the following formula:

$$F = \sum(1/2)^n (1+F_A)$$

Where $\sum$ is the sum of all paths in the relationships through common ancestor; n is the number of individuals in the relationship path connecting the parents of the individual; $F_A$ is the inbreeding coefficient of ancestors.

Generally, the coefficient of inbreeding (F) is half of the coefficient of relationship (r). For example, the coefficient of relationship of incestuous relationship (such as in between father-daughter, mother-son, or brother-sister) shares half of their genetic materials (r=0.5). Therefore, any siblings of such incestuous parents would be homozygous at 1/4 of gene loci (F=0.25). In the case of uncle-niece marriage, both the parents share 1/4 of their genetic components, and hence, the coefficient of relationship (r) is 0.25. On the other hand, the coefficient of inbreeding in their progeny will be half of the coefficient of relationship (r) i.e., F=0.125. Measure of relationship of individuals in terms of consanguinity that is coefficient of relationship and coefficient of inbreeding of different levels of degrees are shown in table 10.1.

**Table 10.1: Relationship of individuals in terms of Consanguinity**

| Biological Relationship | Genetic Relationship | Coefficient of relationship (r) | Coefficient of inbreeding (F) |
|---|---|---|---|
| Incest | 1st Degree | 0.5 | 0.25 |
| Uncle-niece | 2nd Degree | 0.25 | 0.125 |
| First cousin | 3rd Degree | 0.125 | 0.0625 |
| First cousin once removed | 4th Degree | 0.0625 | 0.0313 |
| Second cousin | 5th Degree | 0.0313 | 0.0156 |
| Second cousin once removed | 6th Degree | 0.0156 | 0.0078 |
| Third cousin | 7th Degree | 0.0078 | 0.0039 |

(Source: Adapted from Vogel and Motulsky's Human Genetics, 2010)

## 10.3 BIOLOGICAL CONSEQUENCES OF INBREEDING

Inbreeding is associated with both favourable and unfavourable biological consequences. Studies have reported that consanguineous mating have reduced the rate of intrauterine mortality and also lowered the rates of incompatibility between the mother and foetus. Studies have also shown positive correlation between fertility and consanguineous mating. On the other hand, consanguineous mating also has many adverse health outcomes. Inbreeding has increased the rate of homogeneity among the population, which results in the expression of various deleterious recessive traits. There are numerous examples of recessive traits expressed among the offspring of consanguineously married parents. Some of the common examples of recessive traits expressed among the newborn babies of consanguineous parents are hydrocephalus, albinism, six-fingered dwarfism, tay-sachs, alkaptonuria, cleft lip, and cystic fibrosis. The burden of genetic disorders increase particularly among those societies where consanguineous marriages are culturally accepted. In general, it is a consensus that the progeny of consanguineous parents has a higher rate of postnatal mortality and morbidity. Different studies have also demonstrated a significant positive association between consanguinity and early mortality (*Fareed et al.*, 2017).

Inbred offspring have a higher chance of carrying double dose of a gene inherited from the consanguineously married couple. Carrying of such double dose increases the frequency of recessive trait, which required two copies of allele to express, in the population. Closely related individuals have a higher chance of carrying the same allele than less closely related individuals. Consanguineous children are more frequently homozygous for various alleles than the children of non-consanguineous parents. Children of consanguineously married parents experience several genetic disorders. Consanguinity has social significance in some of the population. However, it has some side effects on the individual as particular and the population as a whole from genetic points of view.

### 10.3.1 Theoretical Consequences

**Short-term and Long-Term effects:** Effects of inbreeding in a population as a result of continuous practice of consanguineous marriages can be of short-term effect, or it can be long-term effect. In the short-term effect, inbreeding increases frequency of homozygosity in the population, and simultaneously, decreases in heterozygosity. Presence of homozygous genotypes enables the expression of recessive traits that were dominated by the dominant allele. Expression of such recessive traits, if deleterious in character, then inbreeding will result in decreasing fitness level. Moreover, inbreeding will also increase in both genetic and phenotypic variability within a population. However, the frequency of recessive homozygous trait will be decreased when the above population continued to practice consanguineous marriage over a period of generations at a constant rate. For example, if the homozygous genotype is deleterious then it will cause premature death before attaining reproductive age. Therefore, the expression of deleterious traits might be lost from the population due to the process of selection. Hence, continuous inbreeding in a population over a long period of generations reduces the frequency of deleterious alleles as a result of long-term effects.

**Genetic load:** Genetic load is defined as the measure of the extent to which the average fitness of a population is decreased. In other words, genetic load measures the rate of damage caused by the presence of certain deleterious genes in the population. According to Crow (1958), genetic load is the relative decrease in the average fitness of a population if all individuals in that population had the genotype that has the maximum fitness. It also measures the total number of disadvantageous genes present in a particular population. The genetic load may be caused by different factors that are based on the types of load that decrease the average fitness of the population. Some of the important types of load includes mutational load (caused by the presence of deleterious mutation in the population); segregation load (caused by the segregation of homozygotes over the heterozygote); recombination load (caused by breakup of favourable gene through recombination); drift load (it is caused by increasing unfavourable allele frequency in small population); and migration load (caused by adaptation to new environment by immigrants).

The deleterious or disadvantage gene reduces the fitness level of the population by causing morbidity, mortality, and sterility. It could happen in two ways, such as may be in heterozygote condition (when the deleterious gene is dominant in character) and in homozygous condition (when the deleterious gene is recessive in character).

### 10.3.2 Studies on Inbreeding Effects in India

In India, various studies have been conducted to understand the effects of inbreeding on consanguineous offspring. Studies have reported that there is a significant decrease in anthropometric variables (birth weight, length, head circumference) and gestational period of newborn babies of the consanguineously married couple than non-consanguineous union (*Badruddoza*, 1998). The mean birth weight, length, head circumference, and gestational period of the babies born to consanguineous couples were significantly lower than non-consanguineous offspring. Congenital birth defects have also been diagnosed among the inbred offspring. Inbreeding increases the mortality rate and serious

congenital disabilities, particularly among the incestuous progeny. In most of the consanguineous marriages, the women were reported to be very young and hence become mothers at a very young age group. It results in gynaecological immaturity and affected both mother and children. Inbreeding may also lead to decline in reproductive and survival rates as a result of increase in expression of rare homozygous recessive traits. Such a condition is known as inbreeding depression. It is also evident that there is increase in numbers of miscarriages or stillbirths among inbred mothers (*Bittles*, 2001). Studies have also reported that postnatal mortality and infant mortality (early first year) is common among the offspring of consanguineously married couples than the mortality in non-consanguineous union (*Hussain et al.* 2001). It could be possibly due to the expression of deleterious recessive genetic traits. Moreover, the infant mortality rate is reported to be highest among the consanguineous offspring, particularly in developing countries.

Cognitive impairment is another typical example of child morbidity among the consanguineous offspring (*Fareed* and *Afzal*, 2014). Moreover, such consanguineous children are also found to have low IQ levels, and intellectual and development disability (IDDs) while comparing with non-consanguineous children (*Durkin et al.*, 1998). Some of the effects and autosomal recessive disorders commonly observed among the consanguineous offspring are shown in the following table 10.2.

**Table 10.2: Studies on biological consequences of Inbreeding in India**

| Author, Year | Population/ State | Associated Disease/Effect | Brief Description of the Disease/Effect |
|---|---|---|---|
| Basu, 1975; Basu and Roy, 1972 | North Indian Muslims | Fertility and Mortality | Fertility rate was higher among the consanguineous marriage than non-consanguineous; with highest mortality rate (below 21 years) among first cousins' consanguineous marriage |
| Kulkami et al., 1989; Jain et al., 1993 | Andhra Pradesh; Pondicherry | Neural tube defects; Congenital development disorders | It is a severe form of congenital disabilities of the brain and spine which happen in the early stage of pregnancy |
| Verma et al., 1992 | Pondicherry | Miscarriage | It is the loss of the foetus before attaining the 20th week of pregnancy. Generally, it happens in the first three months of pregnancy |
| Jain et al., 1993 | Pondicherry | Mental retardation | It is an intellectual disability disorder characterized by a delay in cognitive development |

| | | | |
|---|---|---|---|
| Jain et al., 1993; Badruddoza et al., 1994; Gnanalingham et al., 1999 | Pondicherry; Qureshi (Aligarh); Andhra Pradesh | Congenital heart defects | It is a problem in the structure of the heart at the time of birth. Congenital heart defects are the most common type of birth defects |
| Rahi et al., 1995 | 9 States (Gujarat, Madhya Pradesh, Haryana, Uttar Pradesh, West Bengal, Maharashtra, Karnataka, Kerala and Tamil Nadu) | Early-onset of retinal dystrophies | It is characterized by severe congenital night blindness |
| Chen et al., 1997 | Madras (Chennai), Tamil Nadu | Autosomal recessive hearing loss / deafness (DFNB) | It is very common and accounts for approximately 80% of all congenital deafness. It is the result of a genetic mutation that is inherited from both the mother and the father |
| Homby et al., 2001 | Andhra Pradesh | Anophthalmos | A rare congenital anomaly characterized by the complete absence of one or both eyes |
| Panicker et al., 2002 | Hyderabad, Andhra Pradesh | Primary congenital glaucoma (PCG) | It is characterized by abnormal development of the eye's aqueous outflow system, which leads to elevation of intraocular pressure. It can lead to childhood blindness if untreated |

Sometimes, it is difficult to understand the influence of inbreeding on fertility and mortality since they are also dependent on non-genetic factors, such as maternal age and birth interval. There are several non-genetic variables that influence it. The prevalence rates of genetic disorders among the progeny of consanguineous parents in India are unrepresentative of the actual affected cases because there is paucity of state-level data for all the types of genetic disorders, particularly from rural populations. Moreover, there is paucity of literature on the possible effect of consanguinity on adult-onset of diseases in

India. There are some preliminary literature reporting increased risk of breast cancer and premature coronary heart diseases are more prevalent among the inbred adults. In brief, inbreeding has become one of the strong predictors of the onset of different genetic disorders in both infant and adult populations.

**Check Your Progress**

3) Briefly enumerate the biological consequences of inbreeding.

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## 10.4 PREVALENCE OF INBREEDING IN INDIAN POPULATION

### 10.4.1 Geographical Variation

Consanguineous marriages are practiced in different forms to a greater or lesser extent among most of the religious and ethnic groups living in India (*Sanghvi*, 1966). Inbreeding, the genetical consequences of consanguineous marriage is prevalent in most of the states at different degrees. The rate of consanguineous marriages varies on various factors such as geographical location, religion, caste, tribe, language, socio-economic status, education, culturally isolated, and population size (*Basu*, 1975; *Rao*, 1984). According to NFHS (2015), fourteen percent of marriages in India are consanguineous marriages, which are more common in all of the southern states except Kerala. The people of Kerala practice strict avoidance of consanguineous marriage. The highest frequencies of inbreeding population as a result of consanguineous marriage are reported from south India. About one-third of women in Tamil Nadu, Lakshadweep, Andhra Pradesh, and Telangana reported being in consanguineous marriages. Pondicherry records the highest level of consanguineous marriage (uncle-niece) in a single generation, with 54.9% (*Puri et al.*, 1978). They have a long tradition customary of the first-cousin union that is between a man and his maternal uncle's daughter (*Sastri* 1976). In simple words, it is the mating between a man and his mother's brother's daughter. One of the primary reasons for high rates of consanguineous marriages in south India is a means of ensures the maintenance of their property. It is a common belief that marriage between known and close relatives will helps in strengthening the family ties socially and economically. Moreover, consanguineous marriage is also practiced in order to minimise the dowry in some societies.

There is a wide variation in inbreeding levels within the northern and southern states in India. The consanguineous marriage is preferential among the South Indian population whereas it is prohibited in most of the North Indian population. According to NFHS 4 (2015-16), Tamil Nadu and Lakshadweep record the highest level of inbreeding, reaching up to 33% in India. Arcot district of Tamil Nadu practices the highest frequency of consanguineous marriage in the state.

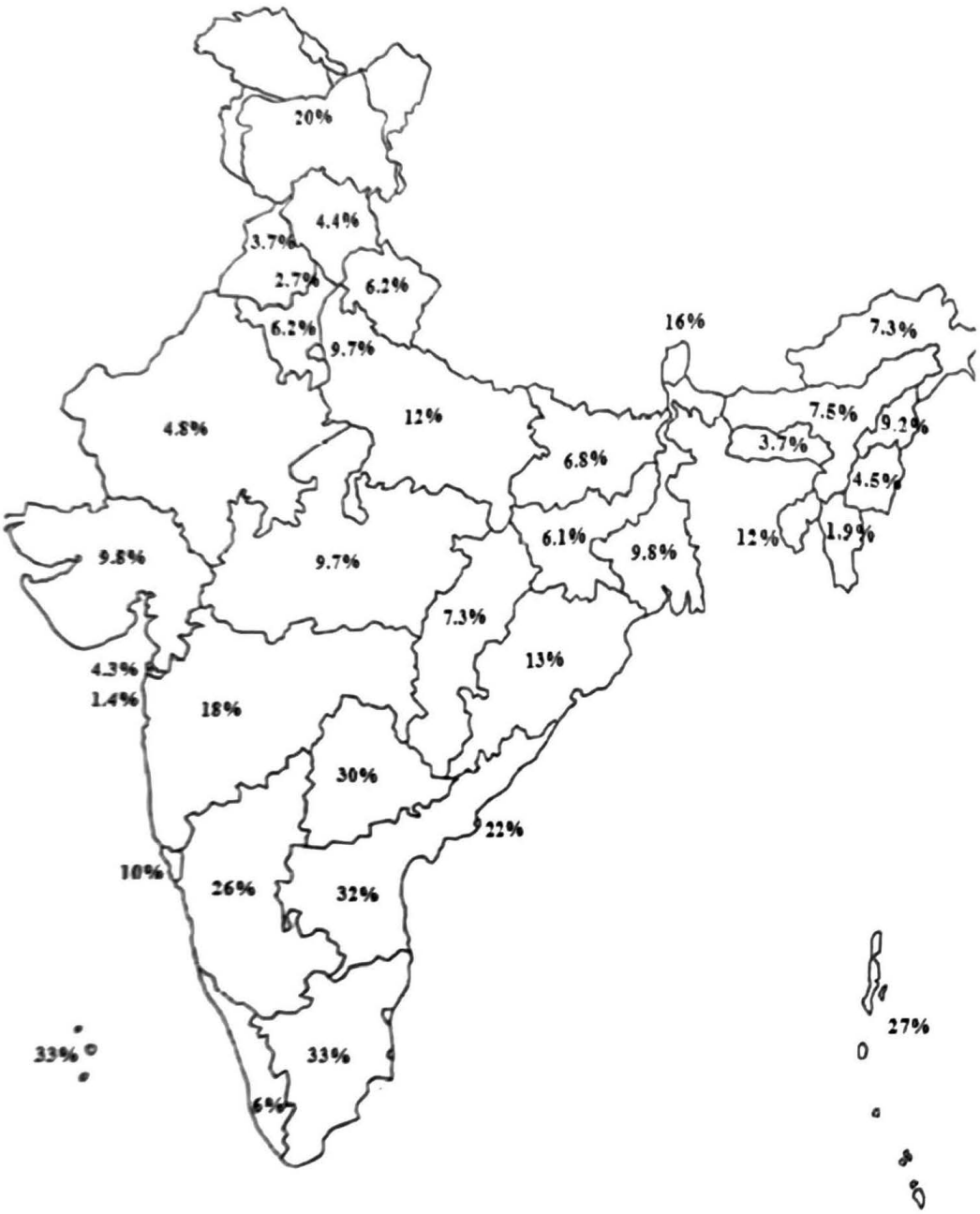


**Fig. 10.2: Map of India showing frequency distribution of consanguineous marriage practices in different states of India**

(Source: adapted from NFHS-4, 2015-16)

The rate of inbreeding decreases when we move from southern states to northern states. Most of the northern states of India record up to 10-12% of inbreeding except Jammu and Kashmir, which reach up to 20% (before separation into union territory in the year 2019). The least frequency of inbreeding in India is recorded from Dadra & Nagar Haveli in western India whereas, Mizoram in the eastern side with only 1.4% and 1.9%, respectively. The rates of consanguineous marriages practice in different states of India are shown in Figure 10.2. Among the different forms of consanguineous marriages, the uncle-niece marriage is most common in south India. Uncle-niece marriages are practiced in high proportions, particularly in the coastal areas of southern India. When we look into the levels of ethnic group, the Dravidian have the highest frequency of consanguinity when compared with other ethnic groups that is the Indo-Aryan, Indo Scythain, and Mongoloid ethnic groups (*Saheb* and *Bhanu*, 1984).

## 10.4.2 Social and Religious Variation

The types of consanguineous marriage practiced by the different religious groups were found to vary. In terms of religious affiliations, Christians showed the lowest rates of inbreeding as there is a strict restriction in close-kin marriage in Christianity. And, the highest rate was recorded among the Muslim population. The frequency of inbreeding is reported to be high among the Asna Ashariya, Shiekh Sunni, Dawoodi Bohra, and Muslims of Delhi and West Bengal (*Basu* and *Roy*, 1972; *Basu*, 1975; *Rizvi* and *Buzarbarua*, 1993). The inbreeding coefficient among Hindus in Tamil Nadu is as high as that found in Andhra Pradesh. In Madhya Pradesh, the Muslim community practices the highest rate of consanguineous marriage, and it is comparatively low among the Hindus (*Goswami*, 1970).

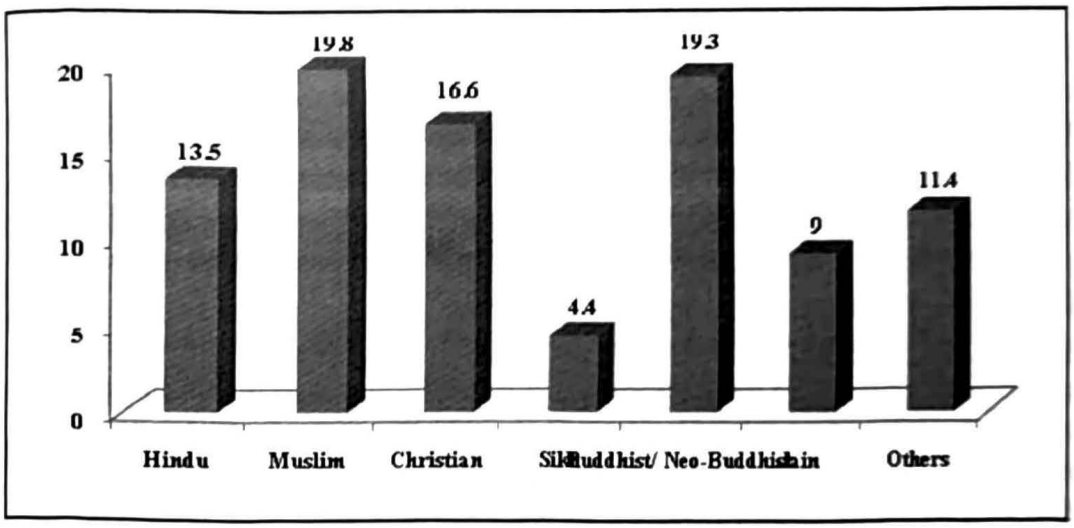


**Fig. 10.3: Distribution of consanguineous marriage practices among the different religious groups of India**

(Source: adapted from NFHS-4, 2015-16)

According to the NFHS 4 (2015-16), the Muslims (19.8%) and Budhist (19.3%) are found to have the highest rate of consanguineous marriage than the other religious groups. Christians and Hindus also represent high frequencies of consanguineous marriage with 16.6% and 13.5%, respectively. The lowest incidence of consanguineous marriage among the major religious groups is represented by Sikh (4.4%). The remaining small religious groups in India constitute 11.4% altogether (Figure 10.3). Using words 'major' and 'small' religious groups are classified truly based on the size of the population compared to the whole Indian population. And, the scheduled castes, Harijans, and Christians are in intermediate between the Muslims and Hindus (*Goswami*, 1970).

Regarding different categories of the Indian population, the rate of consanguineous marriage is observed to be highest among the other backward class (15.1%). It is followed by scheduled caste (14.6%) and schedule tribe population (13.5%). Scheduled tribes have moderate inbreeding levels in general. But, the tribal population of north-east India shows meagre inbreeding rates compare to other parts of India. The 'others' category of the population which are not included in schedule caste, scheduled tribe, and other backward class comprises of 12.8% who practices consanguineous marriage.

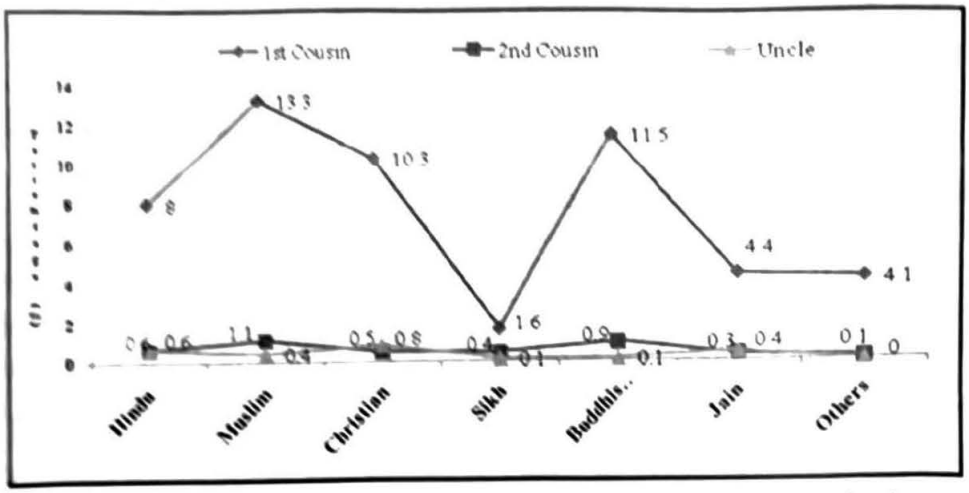


**Fig. 10.4: Distribution of types of consanguineous marriages practice by different religious groups of India**

(Source: adapted from NFHS-4, 2015-16)

When we talk about the practice of various types of consanguineous marriages in India, in general, three types of consanguineous marriages were reported, such as first-cousin, second-cousin, and uncle-niece. The most common type of consanguineous marriage was marriages to first cousins. The first cousin marriage is practiced by most of the religious groups of India. It is highest among the Muslims (13.3%) followed by Budhist (11.5%), Christian (10.3%) and Hindus (8%). The most preferred form of first cross-cousin marriage is maternal uncle's daughter. The majority of the Hindus practice matrilateral cross-cousin marriage, whereas other types of first-cousin were frequent among the other religious groups. For example, Irula of Tamil Nadu has practiced high frequencies of first cross-cousin marriage (43.98%). The different four types of first-cousin union such as to father's brother's daughter (FBD), to father's sister's daughter (FSD), to mother's brother's daughter (MBD) and to mother's sister daughter (MSD) are observed among the Muslim communities (*Bittles*, 2002). The other types of consanguineous marriages, such as second cousin and, uncle-niece are practiced in fewer frequencies irrespective of religion (Figure 10.4). Concerning to different categories of class, other backward class population shows the highest prevalence (9.6%) when compared with scheduled caste (8.8%) and scheduled tribe categories (7.4%) for first-cousin form of consanguineous marriage in India.

**Check Your Progress**

4) Name the state(s) that practice the highest frequency of consanguineous marriage in India?

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## 10.5 SUMMARY

Consanguineous marriage is practiced in India since ancient times. Such marriage is deeply rooted in the beliefs and customs of the society. The prevalence of consanguineous marriage is observed very frequent in some communities,

particularly in South India. Inbreeding is the biological consequences of consanguineous mating. Inbreeding increases the degree of homozygosity and expression of recessive traits. It is evident that consanguineous marriage has genetical disadvantages besides its social and economic benefits. It affects the innocent offspring in particular and the whole community in general.

The control and management of the consequences of inbreeding depends on the identification of the variants in the genome that are causally linked with the disease. However, assessment of biological consequences of inbreeding in terms of morbidity and mortality is still facing lots of problems in our country. It is a challenging mission as the majority of the Indian population are under low socio-economic status, less educated, and appropriate diagnostic facilities are not available in most of the states. Moreover, people could not afford the expenses for diagnosis even if they have the facilities. Therefore, it is an urgent need for counselling for consanguineous parents before family planning, early diagnosis, and proper treatment to decrease the biological consequences. The rate of consanguineous marriage in India could be decreased at some extent by improving educational status as well as improving socio-economic status. It could also be achieved through making awareness at community levels and also developing community education programme.

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## 10.7 ANSWERS TO CHECK YOUR PROGRESS

1) Consanguineous marriage is defined as those marriages which take place between closely related individuals. Such individuals are those who are biologically related and shared their common ancestors. Practicing of consanguineous marriage over a period of time will increase the rate of homozygosity in the population. This will further result into expression of deleterious recessive traits. Moreover, consanguinity will also increase in both genetic and phenotypic homogeneity within a population.

2) The degree of genetic relationship can be measured or quantified by using standardized mathematical formulae. In general, the degree of genetic relationships can be measured by two basic measures such as the coefficient of relationship (r) and coefficient of inbreeding (F).

3) It is evident from various studies that inbreeding results in unfavourable biological consequences to the newborn babies. Most of the consanguineous offspring have been diagnosed with congenital birth defects. It also increases the mortality rate and many other severe birth defects. The chances of miscarriage increase among inbred mothers. It is also evident that postnatal mortality and infant mortality are quite frequent among the offspring of consanguineously married couples than in non-consanguineous union.

4) The highest rates of inbreeding as a result of practicing consanguineous marriage is particularly concentrated in South India. According to the NFHS-4, Tamil Nadu and Lakshadweep record the highest level of inbreeding, reaching up to 33% in India. Arcot district of Tamil Nadu practices the highest frequency of consanguineous marriage in the state.